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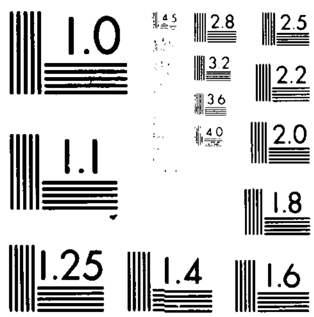

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COST EFFECTIVENESS PROGRAM PLAN FOR JOINT TACTICAL COMMUNICATIONS

VOLUME III

LIFE CYCLE COSTING

JANUARY 1980

USA-USN-USAF-USMC

JOINT TACTICAL COMMUNICATIONS OFFICE
FORT MONMOUTH, N.J.

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This volume serves as TRI-TAC office instructions and guidance to the services and agencies for their preparation, reporting, and tracking of life cycle cost estimates of TRI-TAC systems, subsystems and equipments. It provides formats for reporting TRI-TAC costs in a manner to enhance TRI-TAC financial management and planning by the services/agencies/TRI-TAC Office and ASD (C^3I).

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COST EFFECTIVENESS PROGRAM PLAN

FOR

JOINT TACTICAL COMMUNICATIONS

VOLUME III

LIFE CYCLE COSTING

January 1980

Joint Tactical Communications Office
Fort Monmouth, New Jersey

VOLUME III

This Volume on Life Cycle Costing has been prepared by the staff of the Operations Research Division, Operations Research, Test and Analysis Directorate, TRI-TAC Office.

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SUPERSESSION

This report is an update and a replacement of the April 1978 issue by the TRI-TAC Office.

Table of Contents

Appendices

List of Figures

List of Figures
(Cont'd)

List of Tables

LIFE CYCLE COSTING

FOR

JOINT TACTICAL COMMUNICATIONS SYSTEMS/EQUIPMENT

1.0 INTRODUCTION

The Joint Tactical Communications (TRI-TAC) Office conducts the Cost Effectiveness Program Plan (CEPP) to assist in its overall management of the acquisition of joint tactical communications equipment in conjunction with the Services and Agencies. The role of the TRI-TAC Office and the responsibilities of the Services and Agencies relative to the TRI-TAC Program are presented in DODD 5148.7, "The Joint Tactical Communications (TRI-TAC) Program," January 1978.

The CEPP establishes the procedures and instructions for applying concepts and tools to cost effectiveness analysis, system planning, trade-offs, testing, economic analyses, and cost analyses involved in the development and procurement of future joint tactical communication systems and equipment. The CEPP comprises several TRI-TAC published reports including some devoted to measures of effectiveness, life cycle cost estimating and analyses, threat information, technology forecasts, communication scenarios, risk analyses, and simulation.

Volume 1 [1/] of the CEPP provides an overview of the scope of the Plan as it affects the Services and Agencies, and the TRI-TAC Office. It establishes a joint Service/Agency Cost Effectiveness Coordinating Committee. It also emphasizes that the instructions and guidelines contained in the follow-on volumes should be used in the following areas associated with TRI-TAC systems/subsystems/equipment and related development/acquisition contracts: architectural planning; economic/cost analyses; design and integrated logistic trade-offs; base line and independent costing efforts; program management and planning studies; and decision coordinating papers (DCP). Moreoever, it stresses that the CEPP is useful in the contractual process involving TRI-TAC equipment development and procurement.

Volume II [2/] provides a conceptual model useful for performing effectiveness analyses at the system level for planning and cost-effectiveness studies of joint tactical communications. It also provides guidelines

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1/Joint Tactical Communications Office, Cost Effectiveness Program Plan for Joint Tactical Communications, Vol I - Management Overview, TTO-ORT-032-75-VIA, November 1975.

2/Ibid, Vol II - System Effectiveness, TTO-ORT-032-74-V2, November 1974.

for the modification and application of this model to similar types of problems at the equipment level. The model is also applicable to the design of test programs. It presents joint Service/Agency coordinated Measures of Effectiveness of TRI-TAC programs.

Volume III serves as TRI-TAC Office instructions and guidance to the Services and Agencies for their preparation, reporting, and tracking of life cycle cost estimates of TRI-TAC systems, subsystems, and equipments. It provides formats for reporting TRI-TAC costs in a manner to enhance TRI-TAC financial management and planning by the Services/Agencies/TRI-TAC Office/ and ASD (C^3I).

Since initiation in 1973, the CEPP has established and coordinated the basic joint Service/Agency methods, factors, formats, and definitions for performing cost effectiveness analyses. The Cost Effectiveness Coordinating Committee met several times during 1973-74 and was instrumental in establishing and coordinating Volumes I, II, and III. Most importantly, these volumes have since been effectively applied by the TRI-TAC Office and the Program Manager/System Program Office (PM/SPO) to the contractual planning process of almost all of the TRI-TAC equipment programs. Volume III, in particular, has played an ever increasing role during the DSARC phases of TRI-TAC acquisitions.

An off-shoot of the Cost Effectiveness Coordinating Committee, is the Joint Working Group for Cost Analysis. This group was initiated by the Director of the TRI-TAC Office in 1974, in response to responsibilities assigned to him by DCP 135 for the AN/TTC-39 Program. It comprised representatives assigned by each Service/Agency, most of whom had been members of the Cost Effectiveness Coordinating Committee. The JWG has met periodically each year to work out detailed coordination problems of cost estimating and modeling, cost formatting, and cost reporting, primarily for the AN/TTC-39, but also for some other TRI-TAC Programs such as the TCCF.

1.1 TRI-TAC Life Cycle Cost Concept Development

Life cycle cost estimates for TRI-TAC programs are customarily prepared, justified, and formatted in a variety of ways by each of the Services and Agencies, using their respective costing regulations. The variations in estimating techniques and formats specified by their regulations create unnecessary confusion for efficient centralized financial planning of TRI-TAC programs. Significant errors occur when consolidating and integrating cost estimates from serveral Services/Agencies for budget studies, plans and management decisions, including Defense System Acquisition Review Council (DSARC) decisions. Differences in Service/Agency treatment of, for example, inflation rates, learning curves, and weapon system definitions, make it impossible to show clearly, without a standardized cost concept, the integrated financial impact of changing quantity buys of TRI-TAC programs and other aspects of alternative procurement strategies.

Many years of effort have been spent to define a common cost concept and standard format suitable for presenting total costs of all TRI-TAC programs. In 1972 to 1973, the TRI-TAC Office, under a task

initiated by the Director, and assisted by Booz-Allen Applied Research, began preparation of the TRI-TAC cost structure and life cycle cost model. The intent was to develop one standardized structure, definitions, and model useful for all TRI-TAC equipment programs and by all Services/Agencies. Booz-Allen performed an extensive survey and analysis of a variety of Service/Agency approaches to life cycle costing. (See Section 7, References 1-9 and other sources.) Lists of Service/Agency cost elements, definitions, and methods of estimating were carefully reviewed and correlated. The elements, subelements, and definitions finally established were formally reviewed and commented upon by the Services and Agencies.

The first version of the standardized TRI-TAC cost structure was officially reviewed by OSD PA&E in 1973. They also reviewed and commented upon later issues and have been kept informed about detailed changes. The TRI-TAC elements shown in this particular issue of Volume III have been coordinated with the appropriate CAIG action officers for TRI-TAC DSARC programs. (See Section 7, Reference 13 for further information.)

The TRI-TAC cost concept, structure, definitions of elements, and general methods for estimating and analyzing total costs were prepared in a manner to be sensitive to the particular planning issues and trade-offs involved in TRI-TAC acqusitions. The standardized cost structure is a consolidation of pertinent cost elements of all the participating Services/ Agencies in the TRI-TAC Program and is applicable to all major functional groups of TRI-TAC equipment, such as:

a. Circuit/Message Switches

b. Multichannel Transmission Facilities

c. System/Technical Control Centers

d. Static and Mobile Distribution Facilities

e. Voice/Non-Voice Terminals

f. Associated Communication Security (COMSEC) Equipment.

As mentioned before, the standardized TRI-TAC cost structure with its many detailed cost elements was developed to make it easy for planners, designers, and financial managers to address major issues and decision problems associated with each equipment program. These issues, in very general terms, pertain to broad programatic problems involving quantity procurement, scheduling, risk, and particularly, integration of each equipment program with the other TRI-TAC equipment programs. These issues also pertain to important technical problems involving hardware, software, and ILS design trade-offs.

Some insight into the overall nature of the complexity of the TRI-TAC cost estimating and cost analysis problem can be gained by examining typical "cost drivers" representative of TRI-TAC equipment programs. Table 1 presents a summary list and is not intended to be comprehensive.

TABLE 1

GENERALIZED TRI-TAC COST DRIVERS

	PARAMETER RANKING[1]			
	R&D	PROD	O&S	TOTAL LCC
1 - Hardware Design Characteristics & Requirements				
a - Power Requirement			3	
b - Weight Requirement		3		
c - Size Requirement				
d - Environmental Operating Conditions		2		
e - Electronic Complexity	1			
f - Packaging Density				
g - Reliability Requirements	2	1	2	
h - Automatic vs Manual Operation			1	
i - Survivability/Vulnerability Requirement				
j - External Interface Requirements	3			
k - Component Technology (LSI, MSI, etc.)				
l - Tempest & EMI/EMC Requirements				
m - Maintainability Requirements				
n - Built-in Test Equipment				
2 - Software Design Characteristics				
a - Functional Requirements	1		1	
b - Diagnostic/Built-in Test Requirements	3		2	
c - Program Size Requirement			3	
d - Programming Tools Required				
e - Coding Language	2			
f - Complexity of Coding				
3 - Program Characteristics				
a - Number of Units to be Produced & Delivery Rate	2	1	1	3
b - Length of Total Program		2	2	
c - User Documentation Requirements	3			
d - Beginning & Ending Dates of Each Phase of the Program	1			
e - ECP's		3		
4 - ILS Characteristics				
a - Operating Personnel Requirement	3		3	2
b - Maintenance Personnel Requirement				
c - Repair/Replacement/Discard Policy		2		
d - Repair Parts Requirements		1	2	
e - Initial and Annual Training Policies		3		
f - Automatic & Manual Diagnostics	2			
g - Availability Requirements	1			
h - Equipment Operating Rate			1	1

[1] These are typical parameter rankings. Parameter rankings for a specific program are probably quite different.

Table 1 is a rough indication of the variety of hardware, software, programs, and ILS characteristics which impact R&D, Production, and O&S costs of TRI-TAC equipment programs. Some characteristics are more important than others. These have been ranked to be typically representative of (1) most important, (2) second in importance, and (3) third in importance. The last column shows total Life Cycle Costs and a typical ranking of the three most important of all characteristics has been indicated. The variety of these typical technical and non-technical cost drivers must be accounted for by the elements and definitions of the cost format structure. Only then can proper cost sensitivity studies be performed to aid managers and decision makers.

1.2 Organization of Document

This document is divided into eight sections. Section 1 introduces the TRI-TAC life cycle costing objectives and development of a standardized approach.

Section 2 presents the standardized TRI-TAC life cycle cost structure and the summary and detailed cost formats for DSARC and Cost Analysis Improvement Group (CAIG) requirements.

Section 3 presents the general structure of a TRI-TAC life cycle cost model that can be applied to any tactical communications system or equipment. This section includes a discussion in general terms of cost models, TRI-TAC cost elements, cost estimating and an alternative approach for cost modeling and estimating.

Section 4 presents a general methodology for estimating and analyzing TRI-TAC life cycle costs applicable to long range planning, and equipment design analysis and trade-off studies. It also includes formats for reporting and summarizing life cycle costs for using the TRI-TAC cost structure and elements, and summary formats for presenting costs to the DSARC and the CAIG.

Section 5 presents some special costing techniques, such as the treatment of discounting, inflation, and the learning curve.

Section 6 discusses the relationship between life cycle costing and the DOD "Design-to-Cost" program, including Weapon Systems Costs.

Section 7 is a list of the references and materials used in this document.

Section 8 is a glossary of the acronyms used in this document.

Appendices are included to supplement the information in the body of this document. Appendix A defines the detailed TRI-TAC cost element structure. Appendix B presents the functional cost elements used with the TRI-TAC cost element structure. Appendix C identifies Cost Estimating Relationships (CER's) for the TRI-TAC operating and support cost elements.

Other separate appendices available are: Appendix D,[1] which presents the Services' military personnel and training costs; Appendix E,[2] which presents a CER for transportation costs; Appendix F,[3] which presents a practical computerized cost estimating model; and Appendix G,[4] which presents a computerized technique for treating cost uncertainty.

1.3 Implementation

The Services and Agencies involved in the TRI-TAC Program should use this volume when estimating, analyzing, and reporting the elements of life cycle costs for cost effectiveness studies, trade-offs, engineering change proposals (ECP's), economic/cost analyses, and contractual efforts arising out of the TRI-TAC equipment programs. The formats in Volume III should be used when consolidating total Service/Agency costs for DSARC major TRI-TAC program. The formats should also be used for reporting TRI-TAC costs to the TRI-TAC Office for non-major TRI-TAC programs.

The concepts and CER's of this volume must be applied with judgment, and careful consideration must be given to the current circumstances surrounding the assumed planning factor inputs to each CER. The TRI-TAC life cycle cost elements and formats may require modification to meet specific circumstances, (i.e., contractor trade-offs, DSARC presentations, etc.). The concepts, CER's, formats and procedures of this volume are being reviewed periodically and will continue to be modified to reflect new insight and updated information.

Of special importance, is the fact that the Services and Agencies PM's/SPO's should use the cost formats and cost element definitions presented in this volume for guiding their internal cost accounting and tracking systems. The TRI-TAC formats and definitions are useful to supplement Service/Agency cost methodology so as to prepare commonly understood crosswalks from one Service to another Service. This Volume will help in the preparation of standardized contractor and government recurring and non-recurring costs and weapon system costs, which can be consistently reported and tracked for review by the Director, TRI-TAC Office.

1/TTO, Volume III, LIfe Cycle Costing, Appendix D, Military Personnel and Training Costs, TTO-ORT-032-79B-V3-APD, January 1979.

2/Ibid, Appendix E, Transportation Cost of Spares and Repair Parts, TTO-ORT-032-V3-APE, February 1975.

3/Ibid, Appendix F, Computer Models for LCC, TTO-ORT-032-78B-V3-APF, June 1978.

4/Ibid, Appendix G, Cost Uncertainty Analysis Model, TTO-ORT-032-76-V3-APG, April 1976.

2.0 TRI-TAC LIFE CYCLE COST STRUCTURE

2.1 General Concept

Total TRI-TAC costs as defined by the standard structure reflect the total Services/Agencies resources required and consumed during the complete life cycle of joint tactical communications systems, programs, or items of equipment. In general, TRI-TAC total costs are defined as including all costs of acquisition and ownership of the equipment over its full economic life. Acquisition includes Research and Development and Production. Ownership is defined to include the number of years of field operations of the TRI-TAC equipment and supporting equipment as deployed by the using Services and Agencies.

The TRI-TAC General Life Cycle Cost Structure is divided into three major categories: Research and Development (R&D); Production; and Operations and Support (O&S). These are coded 100, 200, and 300, respectively, as shown in Figure 1. Also shown are the important elements of these major categories with their appropriate numerical code. This general cost structure follows the identical major cost categories in DODI 5000.33.[1] This DODI does not explicitly list elements of these categories in any type of aggregation format, but does mention the kinds of elements normally to be included. The DODI also does not provide definitions of these elements. Figure 1 identifies an intermediate level of aggregation below the major categories and introduces no new elements and is no different than what is included in the DODI. Definitions of elements are shown in Appendix A.

2.1.1 Research and Development Costs

Research and development costs refer to all Government and contractor costs associated with the research, development, test, and evaluation of the system/equipment. Specifically, these cover all costs during the concept initiation, validation, and full-scale development phases of the program. They include costs of feasibility studies, engineering design, development, fabrication, assembly and test of engineering prototype models, initial system evaluation and associated documentation. The costs in this category terminate with the satisfactory completion of testing (Development Test and Initial Operational Test and Evaluation (DTE;IOTE)) and subsequent acceptance by the Government.

The Research and Development costs are divided into non-recurring and recurring costs.

Non-recurring costs refer to R&D costs that are one-time costs incurred during the R&D phase. These costs can be incurred again if there is a change in the design, contractor or manufacturing process.

Recurring costs include those R&D costs that occur with each unit (engineering/development test model) produced by the contractor. These costs tend to be subject to a learning curve concept in which the cost per unit decreases as the quantity produced increased.

[1] DODI 5000.33, Uniform Budget/Cost Terms and Definitions, 15 August 1977.

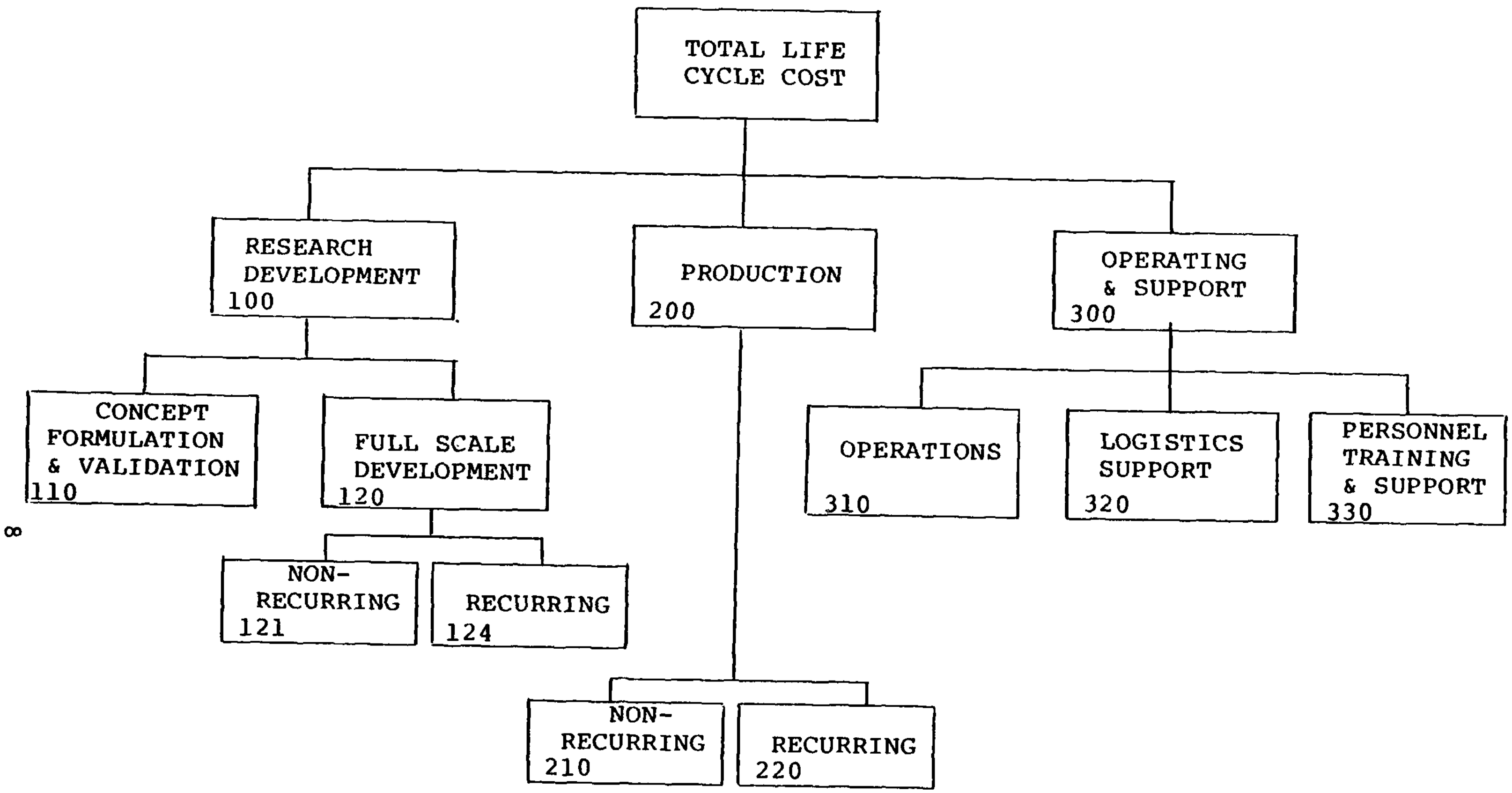

FIGURE 1

STRUCTURE OF TRI-TAC LIFE CYCLE COST CATEGORIES
(See FIGURE 2 for Additional Details)

2.1.2 Production Costs

Production costs refer to those program costs required beyond the development phase to introduce into operational use a new capability to procure initial, additional, or replacement equipment for operational forces, or to provide for major modification of an existing capability. Production costs are further divided into non-recurring and recurring costs.

Non-recurring costs refer to production costs that are one-time costs incurred during the production phase. These costs can be incurred again if there is a change in the design, contractor, or manufacturing process.

Recurring costs include those production costs that occur with each unit produced. These costs tend to be subject to a learning curve concept in which the cost per unit decreases as the quantity produced increases. The costs incurred in this category terminate with the satifactory turnover of an operationally usable system to the using command or organization.

2.1.3 Operating and Support Costs

This category includes the costs of personnel, material, facilities, and other direct and indirect costs required to operate, maintain, and support the equipment/system during the operational phase. It includes the costs of all parts consumed in maintenance of the equipment as well as the costs of maintaining the necessary supply systems for parts, components, equipment, and information.

2.2 TRI-TAC Expanded Cost Structure

The aggregate Life Cycle Cost Structure shown in Figure 1 is shown as a detailed list of cost elements in Figure 2. Definitions are presented for these detailed elements in Appendix A, Section 1 - RDT&E, Section 2 - Production, and Section 3 - Operations & Support. This expands and subaggregates practicallly all of the kinds of detailed elements meaningful for application to TRI-TAC equipment.

2.3 TRI-TAC Cost DCP's and IPS's

Some of the TRI-TAC equipment programs have been and are expected to be designated major DOD acquisitions and will, therefore, be processed for DSARC decisions. The non-major TRI-TAC programs may also follow similar DSARC rules even though development and procurement decisions will be reached at lower management levels. The "Implementing Instructions" issued by the TRI-TAC Office for a particular equipment program at the initiation of development and/or production will stipulate the scope and nature of the cost effectiveness management documents and cost estimates required, including possible compliance with the formats of Volume III of the CEPP.

The Cost Analysis Improvement Group (CAIG) of OSD is the principle advisor to the DSARC regarding all cost and budget data submitted at the time of DSARC milestones. The CAIG reviews the cost submissions to

100 <u>RESEARCH & DEVELOPMENT</u>
- 110 Concept Formulation & Validation
  - 111 <u>Contractor</u>
  - 112 <u>Government</u>
- 120 Full Scale Development
  - 121 Full Scale Development (Non-recurring)
    - 122.1 <u>Contractor</u> (Non-recurring)
      - 122.11 Prime Mission Equip (PME)
        - 122.111 Subsystems (Specify)
      - 122.12 System/Project Management
        - 122.121 System Engineering
        - 122.122 Project Management
      - 122.13 System Test & Evaluation
        - 122.131 Contractor Development Test (CDT)
        - 122.132 Mockups
        - 122.133 Test & Evaluation Support
        - 122.134 Test Facilities
      - 122.14 Training
        - 122.141 Equipment
        - 122.142 Services
        - 122.143 Facilities
      - 122.15 Peculiar Support Equipment
      - 122.16 Data
        - 122.161 Technical Orders & Manuals
        - 122.162 Engineering Data
        - 122.163 Management Data
        - 122.164 Support Data
        - 122.165 Software Support Data
      - 122.17 Other (Specify)
        - 122.171 Contractor G&A
        - 122.172 Contractor Fee
    - 123.1 <u>Government</u> (Non-recurring)
      - 123.11 Program Management
      - 123.12 Test Site Activation
      - 123.13 System Test and Evaluation (DTE/IOTE)
      - 123.14 Government Furnished Equipment (GFE)(Specify)
      - 123.15 Training
      - 123.16 Other (Specify)
  - 124 Full Scale Development (Recurring)
    - 125.1 <u>Contractor</u> (Recurring)
      - 125.11 Prime Mission Equipment (PME)
        - 125.111 Subsystems (Specify)
      - 125.12 System/Project Management
      - 125.13 Initial Spares & Repair Parts
      - 125.14 Other (Specify)
    - 126.1 <u>Government</u> (Recurring)
      - 126.11 Government Furnished Equipment (GFE)(Specify)
      - 126.12 Initial Spares & Repair Parts
      - 126.13 Other (Specify)

FIGURE 2
LIST OF TRI-TAC LIFE CYCLE COST ELEMENTS

200 PRODUCTION
  210 Production (Non-recurring)
    211.1 Contractor (Non-recurring)
      211.11 Prime Mission Equipment (PME)
        211.111 Subsystems (Specify)
      211.12 System/Project Management
        211.121 System Engineering
        211.122 Project Management
      211.13 Training
        211.131 Equipment
        211.132 Services
        211.133 Facilities
      211.14 Peculiar Support Equipment
      211.15 Common Support Equipment (CSE)
      211.16 Data
        211.161 Technical Orders & Manuals
        211.162 Engineering
        211.163 Management
        211.164 Support
        211.165 Software Support
      211.17 Initial Spares & Repair Parts
      211.18 System Test & Evaluation
        211.181 Contractor Acceptance Test (PATE)
        211.182 Contractor OTE Support
      211.19 Software Support Center
      211.20 Other (Specify)
    212.1 Government (Non-recurring)
      212.11 Initial Training
        212.111 Equipment
        212.112 Services
        212.113 Facilities
      212.12 System Test & Evaluation (OTE)
        212.121 Operational Test & Evaluation (OT&E)
        212.122 Government Monitoring of PATE
      212.13 Program Management
      212.14 Test Site Activation
      212.15 Software Center
      212.16 Government Furnished Equipment (GFE)(Specify)
      212.17 Common Government Equipment (CSE)
      212.18 Inventory Management
      212.19 Other (Specify)

FIGURE 2
LIST OF TRI-TAC LIFE CYCLE COST FLEMENTS
(Cont'd)

220 Production (Recurring)
221.1 Contractor (Recurring)
221.11 Prime Mission Equipment (PME)
211.111 Subsystem (Specify)
221.12 System/Project Management
221.121 System Engineering
221.122 Project Management
221.13 Initial Training
221.14 Peculiar Support Equipment
221.15 Common Support Equipment
221.16 Data
221.17 Initial Spares & Repair Parts
221.18 Engineering Changes
221.19 Production Acceptance Test & Evaluation
221.20 Other (Specify)
222.1 Government (Recurring)
222.11 Initial Training
222.12 System Test & Evaluation (OTE)
222.13 System/Project Management
222.14 Initial Spares & Repair Parts
222.15 Common Support Equipment
222.16 Quality Control & Inspection
222.17 Transportation
222.18 Operational Site Activities
222.19 Technical Orders & Manuals
222.20 Goverment Furnished Equipment (GFE)
222.21 Support Engineering
222.22 Other (Specify)

FIGURE 2
LIST OF TRI-TAC LIFE CYCLE COST ELEMENTS
(Cont'd)

300 OPERATIONS & SUPPORT
  310 Operations
    311 Energy Consumption
    312 Material Consumption
    313 Operator Personnel
    314 Operational Facilities
    315 Equipment Leaseholds
    316 Software Support
      316.1 Software Personnel
      316.2 Software Center
    317 Other Operations Costs
  320 Logistic Support
    321 Maintenance
      321.1 Personnel
        321.11 Organizational Maintenance
        321.12 Intermediate Maintenance
        321.13 Depot Maintenance
        321.14 Depot Maintenance (LRU/Mod Rpr)
      321.2 Maintenance Facilities
      321.3 Support Equipment Maintenance
      321.4 Contractor Services
    322 Supply
      322.1 Personnel
        322.11 Organizational Supply
        322.12 Intermediate Supply
        322.13 Depot Supply
      322.2 Sustaining Investments
        322.21 Replenishment Spares
          322.211 Organizational/Intermediate Spares
          322.212 Depot Level Spares
          322.213 Repair Material
        322.22 Modifications
        322.23 Replacement Common Support Equipment
      322.3 Inventory Administration
        322.31 Inventory Mangement
        322.32 Inventory Distribution/Holding
        322.33 Technical Data Support
      322.4 Transportation
    323 Other Logistic Support Costs
  330 Personnel Training & Support
    331 Replacement Training
    332 Health Care
    333 Personnel Activities (PCS)
    334 Personnel Support
    335 Base Operating Support
    336 Other
      336.1 Transients, Patients & Prisioners

FIGURE 2
LIST OF TRI-TAC LIFE CYCLE COST ELEMENTS
(Cont'd)

determine quality and validity of estimates and rationale submitted by the advocating Service or Agency. In the case of major TRI-TAC programs, these submissions are prepared and presented to the CAIG by the designated lead Service/Agency.

A recent issue of DODD 5000.1[1] and DODI 5000.2[2] has included new summary formats for cost and budget estimates to be included in DCP's and IPS's. These formats clarify and expand, beyond previous issues of DODD 5000.1 and DODI 5000.2, the kinds of estimates to be submitted for DSARC's. For joint Service/Agency programs, such as TRI-TAC, additional expansion of the formats is necessary in order to reflect adequately the total life cycle cost and budget impact of several Services/Agencies jointly involved in the same procurement strategy.

The TRI-TAC Office, under the responsibilities outlined in its charter, has incorporated additional but minor expansions of the DODD 5000.1 and DODI 5000.2 formats. These additions will make it easier to present joint Service/Agency total costs and will standardize the exact manner in which each participating Service/Agency will enter their particular cost estimates.

The first summary tables for DCP's, mentioned in DODI 5000.2 as Annex A & B, are presented here with modifications in Volume III as Figures 3 & 4. The Lead Service has the primary responsibility for preparing these tables. Section I of Figure 4 must include total production and delivery quantities entered and designated for each Service. Section II must show costs incurred by Service/Agency and appropriate procurement funding, also by Service/Agency. Section IV will be only a summary of totals of Sections II and III. Section V should be by Service if appropriate. Section VI must show, by Service, total O&S costs aggregated by major budget appropriations. The Section in the DCP format in DODI 5000.2 for MICON has been omitted since for TRI-TAC programs it would most likely never be used. It can be put back any time it is appropriate. All of the summary categories listed here should be obtained from estimates derived for the detailed elements in Figure 2.

Figure 5, is a TRI-TAC modified version of Annex C from DODI 5000.2. The original format has been expanded so as to explicitly treat each Service/Agency involved in whatever alternative plans have been analyzed by the Lead Service, using constant and current dollars. Procurement costs and O&S costs must be provided for each Service/Agency involved.

DODI 5000.2 also provides formats for the IPS. DCP Annex A, B, & C and formats for the IPS have been modified as shown in Figures 3 to 8. All summary estimates must be shown by all Services/Agencies involved in the TRI-TAC program.

1/DODD 5000.1, Major System Acquisitions, 17 October 1979.

2/DODI 5000.2, Major System Acquisition Procedures, 17 October 1979.

	Last Approved by SECDEF 1/			Recommended to SECDEF At This Milestone 2/	
	Goal (a)	Threshold (b)	Current Estimate (c)	Goal (d)	Threshold (e)
COST 3/ 4/					
RDT&E					
for Lead Service/Agency					
Procurement					
for all Services/Agencies Procuring the Program					
Flyaway					
For Lead Service/Agency Procuring the Program					
SCHEDULE 4/ 6/					
Next Milestone					
IOC					
PERFORMANCE 7/					
Operational Availability 8/ 9/					
Mission Reliability 9/ 10/					
Weight					
Power Requirement					
Mobility (Set up/Tear down)					
Operating Rate 11/					
SUPPORTABILITY & MANPOWER 7/					
Manning 12/					
Maintenance-related R&M 9/ 13/					
POL Consumption/Power Consumption					
Spares 14/					

FIGURE 3

DCP ANNEX A FOR TRI-TAC PROGRAMS
GOALS AND THRESHOLDS

Footnotes

1/ Provide Goals and Thresholds from last SDDM.

2/ Explain any changes from columns (a) and (b) in a footnote.

3/ Provide values for total RDT&E and procurement appropriations and for flyaway/rollaway/sailaway cost. Additional cost elements may be appropriate for individual systems.

4/ Add additional stubs as appropriate. The stubs indicated are mandatory.

5/ Provide both a total RDT&E program goal and threshold. Fiscal year thresholds shall be displayed in a footnote to this Annex and shall total to the overall RDT&E threshold.

6/ Provide projected date for next milestone and for 100. Define 100 by footnote. Additional schedule elements may be added, as appropriate.

7/ Select appropriate parameters that drive system effectiveness and costs. The stubs indicated are only examples.

8/ Use readiness-related R&M parameters that consititue operational availability if more appropriate.

9/ Provide goals and thresholds to be achieved by the next milestone. Predicted R&M growth shall be displayed in a footnote to this Annex as a series of intermediate thresholds capable of being measured during development, production, and deployment.

10/ Include mission maintainability if maintenance will be performed during annual mission operation.

11/ Include combat utilization rate if different from peacetime utilization rate (e.g. number of hours operating in field).

12/ Include both operators and maintenance personnel.

13/ Include separate parameters for depot maintenance.

FIGURE 3

DCP ANNEX A FOR TRI-TAC PROGRAMS
GOALS AND THRESHOLDS

	FY 19__ PRIOR	FY 19__	FY 19__	FY 19__	FY 19__	FY 19__	FY 19__	TO COMPLETION	TOTAL PROGRAM
I ACQUISITION QUANTITIES									
Development									
Production									
Deliveries									
II DEVELOPMENT									
Validation Phase									
Full-Scale Development									
Total Development Cost 1/									
RDT&E Funding (Approved FYDP)									
III PRODUCTION									
System Cost by Service/Agency 2/									
(Long Lead Requirements)	(A non-add entry for each fiscal year)					( )	( )	( )	( )
Initial Spares									
Total Procurement Cost by Service/Agency 1/									
Procurement Funding by Service/Agency (Approved FYDP)									
IV Total Program Acquisition Cost 1/									
RDT&E, Procurement and MILCON Funding (Approved FYDP)									
Difference (See Service/Agency Amounts above)									
V Estimates Other Resources Requirements 3/									
During Development									
During Production									
VI OPERATING & SUPPORT (By Service/Agency)									
O&M									
MILPERS									
Procurement 4/									
Total Operating & Sypport Cost 1/									
VII Total Life Cycle Requirements									

1/ Definitions should be in accordance with DoD Instruction 5000.33.
2/ Equal to Weapon System Cost as defined in DoDI 5000.33.
3/ Other Life Cycle related costs (i.e., Installation, Project Manager Office, Civilian Salaries, Etc.) funded by other appropriations; e.g., O&M, MILPERS, during development and/or Production phase. Also, Production Base Support (Industrial Facilities), shore-based training facilities, and other system peculiar costs identified as a separate line item, or as a portion of a separate line item, in another part of the Procurement Budget.
4/ Procurement costs associated with operation/owning a weapon system such as modifications, replenishment spares, ground equipment, etc.

FIGURE 4

DCP ANNEX B FOR TRI-TAC PROGRAMS
LIFE CYCLE COST

(Prepared by Lead Service with Cooperation from Other Using Services)

CONSTANT DOLLARS (MILLIONS)

ALTERNATIVE	DEVELOPMENT Lead Service/Agency	PRODUCTION Lead Service/Agency	PRODUCTION Other Procuring Service	O & S Army	O & S AF	O & S Navy	O & S MC	TOTAL LCC
A 1								
A 2								
A 3								
o								
o								
o								

CURRENT DOLLARS (MILLIONS)

ALTERNATIVE	DEVELOPMENT Lead Service/Agency	PRODUCTION Lead Service/Agency	PRODUCTION Other Procuring Service	O & S Army	O & S AF	O & S Navy	O & S MC	TOTAL LCC
A 1								
A 2								
A 3								
o								
o								
o								

FIGURE 5

DCP ANNEX C FOR TRI-TAC PROGRAMS
LIFE CYCLE COST FOR ALTERNATIVE PLANS

(TRI-TAC Program)

	FY CONSTANT (BASE YEAR) $			ESCALATED $
	Planning/ Development Estimate 2/	SDDM (Date) 3/	Current Estimate 4/	Current Estimate 4/
DEVELOPMENT PHASE				
RDT&E				
Validation Phase				
Full Scale Development				
Contractors				
(Provide one level of WBS indenture based on program requirements)				
In-House				
(Provide one level of WBS indenture based on program requirements)				
Contingency (Service)				
TOTAL RDT&E APPROPRIATION				
MILCON				
O&M 5/				
MILPERS 5/				
TOTAL DEVELOPMENT PHASE				
PRODUCTION PHASE				
PROCUREMENT				
System Cost 7/				
Flyaway				
(Provide one level of WBS indenture based on program requirements)	( ) 6/	( ) 6/	( ) 6/	( ) 6/
Other System Costs				
Initial Spares				
Other Line Item Procurement 8/				
TOTAL PROCUREMENT APPROPRIATION				
MILCON				
O&M 5/				
MILPERS 5/				
TOTAL PROCUREMENT PHASE				
TOTAL OPERATING & SUPPORT PHASE FOR ALL SERVICES BUYING				
Army				
Navy				
Air Force				
Marine Corps				
TOTAL LIFE CYCLE REQUIREMENTS				
Army				
Navy				
Air Force				
Marine Corps				
AVERAGE ANNUAL SYSTEM O&S COSTS (BY SERVICE)				
No. of Systems: No. of Years:				

FIGURE 6

IPS ANNEX A
Modified for TRI-TAC
RESOURCE - COST TRACK SUMMARY 1/
(Millions of Dollars)

(TRI-TAC Program)

Footnotes

1/ Apply footnotes as required to explain the chart. Adjustments to format are authorized to accommodate program; stub entries will be decided on at the initial Milestone Planning Meeting. Definitions should be in accordance with DoD Instructions 5000.33.

2/ Identify basis for estimate and date of SDDM.

3/ Add columns as necessary for each SDDM revision.

4/ The preferred alternative or the latest approved baseline cost estimate contained in the SDDM will be shown in both constant and current (escalated) estimate columns.

5/ Other Life Cycle related costs (i.e., Installation, Project Manager Office, Civilian Salaries, etc.) funded by O&M and MILPERS during Development and/or Production phase.

6/ Enter Quantity.

7/ Equal to Weapon System Cost as defined in DoDI 5000.33.

8/ Production Base Support (Industrial Facilities) or System hardware such as Trainers, Guns, Engines, etc., identified as a separate line item in another part of the Procurement Budget but are system peculiar.

NOTE: Reasons for significant variations in estimate should be explained by footnote (e.g., schedule slippage, Congressional funding, etc.).

FIGURE 6

IPS ANNEX A
Modified for TRI-TAC
RESOURCE - COST TRACK SUMMARY 1/
(Millions of Dollars)

(TRI-TAC Program)

	FY 19__ PRIOR	FY 19__	FY 19__	FY 19__	FY 19__	FY 19__	FY 19__	TOTAL PROGRAM	
Acquisition Quantities to be Procured 2/									
Development									
Production - Army									
Navy									
Air Force									
Marine Corps									
Deliveries									
DEVELOPMENT PHASE									
RDT&E									
Validation Phase									
Full Scale Development									
Flyaway									
Other System Costs									
TOTAL RDT&E APPROPRIATION									
MILCON									
O&M 3/									
MILPERS 3/									
TOTAL DEVELOPMENT PHASE									
PRODUCTION PHASE									
PROCUREMENT 4/									
System Cost 5/									
Flyaway									
Other System Costs									
Initial Spares									
Other Line Item Procurement 6/									
TOTAL PROCUREMENT APPROPRIATION									
MILCON									
O&M 3/									
MILPERS 3/									
TOTAL PRODUCTION PHASE									
OPERATING & SUPPORT PHASE									
MILPERS - Army									
Navy									
Air Force									
Marine Corps									
O&M - Army									
Navy									
Air Force									
Marine Corps									
Procurement 7/									
TOTAL OPERATING & SUPPORT PHASE									

Annex to be completed for each alternative
1) In Constant (Name) year dollars
2) In Escalated dollars using current FYDP rates and ground rules

FIGURE 7

IPS ANNEX D
Modified for TRI-TAC
RESOURCE - FUNDING PROFILE 1/
(Dollars in Millions)

(TRI-TAC Program)

<u>Footnotes</u>

1/ Apply footnotes as required to explain the chart. Adjustments to format are authorized to accommodate program, stub entries will be decided on at the initial Milestone Planning Meeting. Defintions should be in accordance with DoD Instruction 5000.33.

2/ Identify the number of Development and Production units to be acquired by fiscal year.

3/ Other Life Cycle related costs (i.e., Installation, Project Manager Office, Civilian Salaries, etc.) funded by other appropriations; e.g., O&M and MILPERS during Development and/or Production phase.

4/ Enter the costs by appropriation e.g., Aircraft, Procurement, Missile Procurement, SCN or Other Procurement. If more than one applies, identify it separately.

5/ Equal to Weapon System Cost as defined in DoDI 5000.33.

6/ Production Base Support (Industrial Facilities), shore-based training facilities, and other system peculiar costs identified as a separate line item, or as a portion of a separate line item, in another part of the Procurement Budget. Identify the content of this entry.

7/ Enter the costs in same order as in Footnote 4/

FIGURE 7

IPS ANNEX D
Modified for TRI-TAC
RESOURCE - FUNDING PROFILE
(Dollars in Millions)

(TRI-TAC Program)

ALTERNATIVES/ TECHNICAL APPROACH/ EQUIPMENT/ SYSTEM/ ETC.	RESEARCH & DEVELOPMENT COSTS		INVESTMENT COSTS		OPERATING & SUPPORT COSTS		LIFE CYCLE COST ESTIMATE
	VALIDATION	FS DEVELOPMENT	NON-RECURRING	RECURRING	OPERATION	LOGISTIC SUPPORT	
1	Enter Values from LCC Element Estimates						
2							

FIGURE 8
LCC ESTIMATE DOCUMENTATION SUMMARY
FOR (Name of) PROGRAM

2.4 TRI-TAC Costs for DSARC/CAIG Backup Presentations for Major Programs

The DCP and IPS summary cost and budget formats described in the previous section must be backed up with adequate cost element details and cost discipline, meaning, in this case, valid and trackable methodology, rationale, and source material. The cost structure in Figure 2 should be used by a Service's PM or SPO in the initial plans in estimating TRI-TAC life cycle costs, therefore setting up the proper foundation. Elements can be aggregated and identified by Budget Category in order to arrive at the summary tables in Section 2.3.

Additionally, and most importantly, the CAIG requires presentations and backup reports in sufficient details for their analyses prior to the DSARC meetings. The presentations must provide adequate cost element breakout and estimating rationale, all trackable to the DCP/IPS summary totals to facilitate their short time availability.

Because of the multiple Service/Agency nature of TRI-TAC program acquisitions, standardized cost formats and cost definitions serve as a useful basis for inter-Service/Agency mutual understanding of each others costing methodology. A standardized format, which organizes all types of cost elements of all Services/Agencies involved in TRI-TAC programs provides a structured aggregation technique to guide the preparation of cost estimates throughout the life cycle acquisition process. These standardized formats are shown in Figures 9 through 11 and essentially, duplicate the list in Figure 2 in a data entry style. Level 3 should be available for DSARC.

Two summary tables must supplement Figures 9 through 11 for CAIG presentation of TRI-TAC costs. Figures 12 and 13 should also be completed. Figure 12 can be filled in directly from estimates in the Figures 9 through 11 outline.

The CAIG has indicated that there is a need to create an electronics data base for DOD. An established electronics data base would allow better DOD cost estimations of electronic systems acquisitions using those techniques which are explained in Section 3.2. This electronic data base would be established by using the Contractor Cost Data Reporting (CCDR) system. The data from the TRI-TAC program contractors would be very beneficial to this data base, since the TRI-TAC programs are developing basically digital electronics equipments using the latest available technology.

The TRI-TAC Life Cycle Cost structure, its elements, definitions, and formats are compatable with the CCDR system. 1/

1/NAVMAT P-5241, AMCP 71-58, AFLCP/AFSCP 800-15, Contractor Cost Data Reporting (CCDR) System Pamphlet, 5 November 1973.

TRI-TAC LIFE CYCLE COST ELEMENT STRUCTURE	COSTS IN (K) OF CONSTANT 19 $				
	LEVEL 3 WBS	LEVEL 2 WBS	SUB ELEMENT	ELEMENT	CATEGORY
100 RESEARCH & DEVELOPMENT					
110 Concept Formulation & Validation					
111 Contractor					
112 Government					
120 Full Scale Development					
121 Full Scale Development (Non-recurring)					
122.1 Contractor (Non-recurring)					
122.11 Prime Mission Equip (PME)					
122.111 Subsystem (List Costed Subsystems)					
122.12 System/Project Mgmt					
122.13 System Test & Eval (CDT)					
122.14 Training					
122.15 Peculiar Support Equip					
122.16 Data					
122.17 Other (Specify)					
123.1 Government (Non-recurring)					
123.11 Program Management					
123.12 Test Site Activation					
123.13 System Test & Eval (DTE/IOTE)					
123.14 Govt Furnished Equip (GFE) (Specify)					
123.15 Training					
123.16 Other (Specify)					
124 Full Scale Development (Recurring)					
125.1 Contractor (Recurring)					
125.11 Prime Mission Equip (PME)					
125.111 Subsystem (List Costed Subsystems)					
125.12 System/Project Management					
125.13 Initial Spares & Rpr Pts					
125.14 Other (Specify)					
126.1 Government (Recurring)					
126.11 Govt Furnished Equip (GFE) (Specify)					
126.12 Initial Spares & Rpr Pts					
126.13 Other (Specify)					
TOTAL RESEARCH & DEVELOPMENT COSTS					

FIGURE 9

TRI-TAC LIFE CYCLE COST SUMMARY FORMAT
RESEARCH & DEVELOPMENT COSTS

FOR ______ (Name of) ______ PROGRAM

TRI-TAC LIFE CYCLE COST ELEMENT STRUCTURE	COSTS IN (K) OF CONSTANT 19 $ LEVEL 3 WBS	LEVEL 2 WBS	SUB ELEMENT	ELEMENT	CATEGORY
200 PRODUCTION					
210 Production (Non-recurring)					
211.1 Contractor (Non-recurring)					
211.11 Prime Mission Equip (PME)					
211.111 Subsystem (List Costed Subsystem)					
211.12 System/Project Mgmt					
211.13 Training					
211.14 Peculiar Support Equip					
211.15 Common Support Equip (CSE)					
211.16 Data					
211.17 Initial Spares & Rpr Pts					
211.18 System Test & Eval (Incl PATE)					
211.19 Software Support Center					
211.20 Other (Specify)					
212.1 Government (Non-recurring)					
212.11 Initial Training					
212.12 System Test & Eval (OTE)					
212.13 Program Management					
212.14 Test Site Activation					
212.15 Software Center					
212.16 Govt Furnished Equip (GFE) (Specify)					
212.17 Common Support Equip					
212.18 Inventory Management					
212.19 Other (Specify)					
220 Production (Recurring)					
221.1 Contractor (Recurring)					
221.11 Prime Mission Equip (PME)					
221.111 Subsystem (List Costed Subsystems)					
221.12 System/Project Management					
221.13 Initial Training					
221.14 Peculiar Support Equip					
221.15 Common Support Equip					
221.16 Data					
221.17 Initial Spares & Rpr Pts					
221.18 Engineering Changes					
221.19 Production Accept Test & Eval					
221.20 Other (Specify)					
222.1 Government (Recurring)					
222.11 Initial Training					
222.12 System Test & Eval (OTE)					
222.13 System/Project Management					
222.14 Initial Spares & Rpr Pts					
222.15 Common Support Equipment					
222.16 Quality Control & Inspection					
222.17 Transportation					
222.18 Operational Site Activities					
222.19 Technical Orders & Manuals					
222.20 Govt Furnished Equip (GFE) (Specify)					
222.21 Support Engineering					
222.22 Other (Specify)					
TOTAL PRODUCTION COSTS					

FIGURE 10

TRI-TAC LIFE CYCLE COST SUMMARY FORMAT
PRODUCTION COSTS

FOR ______(Name of)______ PROGRAM

TRI-TAC LIFE CYCLE COST ELEMENT STRUCTURE	COSTS IN (K) CONSTANT 19 $				
	LEVEL 3 WBS	LEVEL 2 WBS	SUB ELEMENT	ELEMENT	CATEGORY
300 OPERATING & SUPPORT					
310 Operations					
311 Energy Consumption					
312 Material Consumption					
313 Operator Personnel					
314 Operational Facilities					
315 Equipment Leaseholds					
316 Software Support					
316.1 Software Personnel					
316.2 Software Center					
317 Other Operations Costs					
320 Logistic Support					
321 Maintenance					
321.1 Personnel					
321.11 Org Maintenance					
321.12 Int Maintenance					
321.13 Depot Maint (Overhaul)					
321.14 Depot Maint (LRU/Mod Rpr)					
321.2 Maintenance Facilities					
321.3 Support Equip Maintenance					
321.4 Contractor Services					
322 Supply					
322.1 Personnel					
322.11 Org Supply					
322.12 Int Supply					
322.13 Depot Supply					
322.2 Sustaining Investments					
322.21 Replenishment Spares					
322.22 Modifications					
322.23 Replacement Common Spt Eq					
322.3 Inventory Administration					
322.31 Inventory Management					
322.32 Inv Distribution/Holding					
322.33 Technical Data Support					
322.4 Transportation					
323 Other Logistic Support Costs					
330 Personnel Training & Support					
331 Replacement Training					
332 Health Care					
333 Personnel Activities (PCS)					
334 Personnel Support					
335 Base Operating Support					
336 Other					
336.1 Transients, Patients & Prisoners					
TOTAL OPERATING & SUPPORT COSTS					

FIGURE 11

TRI-TAC LIFE CYCLE COST SUMMARY FORMAT
OPERATING & SUPPORT COSTS

FOR: ______(Name of)__________ PROGRAM

FISCAL YEAR	ELEMENT COSTS			TOTAL DOLLARS (1)	PRICE INDEX (2)	(1) X (2) INFLATED DOLLARS (3)	DISCOUNT FACTOR (4)	(3) X (4) TOTAL INFLATED/ DISCOUNTED DOLLARS
	R & D	INV.	O & S					
1974	$XXX			$XXX	–	$XXX	–	$XXX
1975	$XXX			$XXX	–	$XXX	–	$XXX
1976	$XXX	$XXX		$XXX	–	$XXX	–	$XXX
1977		$XXX		$XXX	–	$XXX	–	$XXX
1978		$XXX	$XXX	$XXX	–	$XXX	–	$XXX
1979		$XXX	$XXX	$XXX	–	$XXX	–	$XXX
1980			$XXX	$XXX	–	$XXX	–	$XXX
1981			$XXX	$XXX	–	$XXX	–	$XXX
1982			$XXX	$XXX	–	$XXX	–	$XXX
1983			$XXX	$XXX	–	$XXX	–	$XXX
1984			$XXX	$XXX	–	$XXX	–	$XXX
1985			$XXX	$XXX	–	$XXX	–	$XXX
1986			$XXX	$XXX	–	$XXX	–	$XXX
1987			$XXX	$XXX	–	$XXX	–	$XXX
TOTAL	$XXXX	$XXXX	$XXXX	$XXXXX	–	$XXXXX	–	$XXXXX

FIGURE 12
LCC SUMMARY BY FISCAL YEAR
ALTERNATIVE XXX
FOR (Name of) PROGRAM

Cost Element	R&D					PRODUCTION				
	Unit Prod Cost/Qty	R&D Qty	Non-Recur $	Recur $	Total $	Unit Prod Cost/Qty	Qty	Non-Recur $	Recur $	Total $
Hardware										
Subsystems (Specify)										
Total Hardware										
Support										
Initial Spares										
Training										
Data										
Peculiar Support										
Common Support										
Operation/Site Activation										
Military Construction										
Other (Specify										
Total Support										
TOTAL PROGRAM ACQUISITION										

FIGURE 13

SUMMARY OF ACQUISITION COSTS FOR __(Name of)___ PROGRAM
(Constant FY 19__ (M) Dollars)

2.5 TRI-TAC Costs for Non-Major Programs

The policies, instructions, formats, etc., of DODD 5000.1 and DODI 5000.2, are applicable, where appropriate, to the acquisitions of systems not designated as major. Therefore, as a general rule, the TRI-TAC modified cost formats shown previously in Section 2.5 will also apply to non-major TRI-TAC programs.

The level of detailed cost element estimates required from the lead Service may be modified, say to Level 2 or Level 1 only, to reflect essential decision making requirements of a particular program. Some reduction in even the extent of Level 2 estimates may be made and some Level 2 estimates may be aggregated to reduce the amount of non-critical cost estimating effort. However, any reduction in details should not compromise the responsibility of the lead Service to establish credibility of the estimates and to prepare clear rationale for significant changes from one reporting period to another. It is more likely that adjustments will be made to the general cost estimating methodology and the utilization of parametric rather than bottom-up estimating techniques.

3.0 ESTIMATING TRI-TAC COSTS VIA THE TRI-TAC LIFE CYCLE COST MODEL

3.1 General Concept

Cost models, in general, provide essential frameworks of elements, factors, and equations useful for engineers, operations research analysts, and cost analysts to analyze and estimate the resource requirements of proposed future systems, subsystems, and equipment in terms of dollars. There are many kinds of cost models and many levels of cost aggregation covered. A life cycle cost model deals with estimating total costs associated with the life cycle of systems, equipment, etc. It differs from other cost models in that all costs are considered, from conception, development, acquisition, and lifetime ownership.

Two factors influence in a significant way, the scope of a life cycle cost model. These factors are (1) the intended use of the model and (2) the availability of data, both for preparation of the CER's and as inputs to the CER when estimating costs.

The TRI-TAC Life Cycle Cost Model, described fully in Appendix F, was designed to utilize the structure of Figure 2 and satisfy several intended uses. First, it serves long range planning and analysis needs of primarily ASD (C^3I) and the TRI-TAC Office. These needs arise, in part, from the normal responsibilities as top level managers, architects, and integrators of the TRI-TAC programs and as users of the cost estimates prepared for these programs by the Services/Agencies. Needs also arise from internal study efforts of these two offices which may involve the preparation of cost estimates not otherwise issued by a Service/Agency.

Often gross estimates of program and equipment costs are sufficient as long as it is cearly understood which subelements of costs have been included and which major cost factors, such as price level or inflation factors have been used. Detailed and accurate estimates of "far-out" programs may be infeasible. The TRI-TAC Life Cycle Cost Model was developed and organized so as to assist in both managing the Service/Agency efforts and in preparing gross estimates for long range planning of architectural alternatives and ultimate systems of equipment.

Secondly, the TRI-TAC Life Cycle Cost Model was developed to satisfy Service/Agency needs for preparing cost estimates for near term studies of equipment design trade-offs and for evaluating ECP's. These require more detailed and more accurate estimates of life cycle costs. A model that serves these different uses requires a greater degree of flexibility of structure than a limited use model.

The availability of data for the system or equipment to be costed and for analogous historical systems affects the structure and content of the model and can be the driving force behind the selection and/or development of the CER's. Even if appropriate data was available, there are still many aspects about the validity, credibility, and accuracy of the data which influence the design of the model. Therefore, cost analysts who use the TRI-TAC cost model should examine the extent of the cost elements and the specific CER's in light of the availability and credibility of input data.

3.2 Cost Estimating Relationships

Estimates of cost elements can be prepared by several techniques. One of the most common technique is a cost estimating relationship (CER).[1] A CER is an analytical device that relates the value (in dollars or physical units) of various cost categories to the cost-generating or explanatory variables associated with the categories. There are several major types of cost estimating techniques: parametric, industrial engineering, analogy, and expert opinion. Each technique is discussed in the following text.

3.2.1 Parametric Cost Estimating Relationships

A parametric or statistical CER can be derived for new systems/equipments if there are historical data from prior systems/equipments that are functionally similar. These extrapolations take many forms depending on the skill of the analyst. Where skill and/or data are sparse, extrapolation may be based on the relationship between the cost of a single previous system and its physical or performance characteristics, such as weight or transmission power. As skill in developing cost estimating relationships and/or data increase, the number of previous systems and the number of physical and performance characteristics will increase until a full scale multiple regression approach is applied. The basic premise of this procedure is that costs of a system are related in a quantifiable way to its physical and performance characteristics and not upon a detailed estimate of the cost of each building block -- some of which may be underdefined -- in the system. Linear, curvilinear, logarithmic, or exponential are the most commonly applied regression techniques. After a parametric relationship has been derived, it can be used to estimate the costs associated with the new system by direct substitution into the equation of the cost, performance, and physical parameter data of the new system. It should be noted that in certain cases, boundary conditions plan an important role in parametric CER's. It is not unusual to require that parameter values stay within specific ranges for the relationships to hold true.

An example of a parametric CER which calculates the production cost at the 100th unit of troposcatter equipment in the 4400-5000 MHz range in 1969 dollars is the following equation:[2]

$$Y = 222045.7 + 19.973X_1 + 3427.170X_2 + 1084.160X_3$$

where:

Y = Unit Production Cost of Equipment at the 100th Unit

X_1 = Average RF Power in Watts

[1] Fisher, G. H., Cost Considerations in Systems Analysis, RAND Corporation, R-490-ASD, December 1970, P. 123.

[2] Northrop, et al, Methodology for Systems Analysis of the MALLARD Communication System, Final Report. Vol IV, Costs, Westinghouse Electric Co., Baltimore, MD, April 1969.

X_2 = Average Diameter in Feet

X_3 = Number of Channels

The unit production cost of the equipment can be computed by estimating the value of X_1, X_2, and X_3. The coefficients in the equations were prepared based on an analysis of historical data of appropriate equipment.

3.2.1.1 The Availability of Parametric Relationships

Historical data may not be available, or may be available in differing work breakdown or accounting structures. Also, there can be various inconsistencies and irregularities in the data that must be resolved in order to insure consistent and comparable data base. If there are little or no data, there are no sophisticated mathematical techniques that can make up this deficiency.

There usually is a degree of statistical uncertainty in the use of parametric relationships. The statistical measures pertaining to the regression equation used to derive the parametric relationship will aid the analyst in estimating this uncertainty. Examples of these statistical measures are: 1/

1. The standard error of estimate.

2. The relative standard error of estimates.

3. The standard errors of the regression coefficients.

4. The Beta coefficients, if appropriate to the distribution.

5. The equation for the standard error of forecast.

6. The coefficient of multiple determination.

7. The coefficient of multiple correlation.

Parametric CER's provide a means of extrapolating from past experience to estimate the costs of future systems and equipment. They do not provide an exact "answer". The analysts must correctly interpret the basis for their derivation and the uncertainty about the results if an accurate estimation of costs is to be made.

3.2.1.2 Advantages of the Parametric Approach

The record of cost estimates prepared using the detailed engineering approach suggests that parametric or partially parametric procedures are to be preferred. This is particularly true when the required

1/ More detailed treatments of regression analysis and uncertainty can be found in: Bonini & Spurr, Statistical Analysis for Business Decisions; and Draper & Smith, Applied Regression Analysis. (See Section 7.0, References 23 & 24.)

performance characteristics of the new system are considerably beyond those achieved by previous equipment or when a development program incorporates a variety of technological innovations. In these cases, experience has shown that the final product differs substantially from all conceptions of its configuration during preliminary design; that early conceptions fail to recognize all the complexities and setbacks involved in making the new total system operational and, hence, underestimate its costs. Parametric estimates have the advantage of being developed from a set of the sample points which reflect the delays, problems, mistakes, redirections, and changing characteristics of high performance systems development. Use of parametric cost estimating relationships to estimate new programs therefore takes into account the statistical average of such experience on prior programs. The more aggregate level at which parametric cost projections are made is actually an advantage in the case of such systems, since the design details on which industrial engineering procedures are based usually undergo several transformations in the course of the development process.

It is the only method that can be used to make an estimate from the limited data information available during concept formulation, i.e., when only mission and performance envelopes are defined. In addition, parametric methods provide the analyst with an inexpensive means of examining the impact on cost of a variety of changes in system performance requirements -- information of particular importance during the early phases of the devleopment process.

3.2.1.3 Disadvantages of the Parametric Procedure

Formal parametric procedures also have some well known limitations. To be fully effective, they require an extensive base of past costs and performance data. Also, their use implies that the relationships which existed in the sample on which the estimating equations were based will continue to exist in the future. Extrapolations which involve systems with a large advance in the state of the art become increasingly hazardous the more they depart from the technology which existed at the time the sample programs were procured. In those cases the techniques should be used as a base estimate to which adjustments should be made to allow for the non-applicability of past experience.

In particular, the digital communications equipment of the future may not follow the parametric relationships derived from the analog equipments of the past. The estimating relationships should be only the starting point in the estimating process. The first estimate will then have to be modified in the light of supplementary qualitative and quantitative data to fit the system or equipment at hand.

3.2.2 Industrial Engineering Cost Estimating Relationships

In the past, the principle technique used to support cost estimates associated with electronic systems has been the industrial engineering approach, which relies on detailed simulation of all the operations required to develop and produce a unique and specifically defined piece of equipment. This procedure makes use of vendor quotes, manloading requirements

by work center and station, standards built up from time and motion studies, etc., and is sometimes referred to as "grass roots" or "bottom up" estimating. In many cases, the estimating is done by a contractor.

The advantages of the engineering cost estimating procedures are that:

1. They can provide accurate cost projections of "off-the-shelf" equipment when detailed information is available.

2. The method can be applied independently to the various detailed functional cost elements of the system or equipments. Thus, as more detailed information becomes available for specific elements, initial parametric cost estimates can be refined or replaced by engineering estimates or actual costs to arrive at a better cost picture.

The disadvantages of the engineering cost estimating procedures, in addition to those mentioned in Para. 3.2.1.2, are that:

1. The engineering estimate method cannot be used until detailed cost input data is available. By the time this information is available, past decisions might preclude certain attractive courses of action.

2. They are usually more costly and time consuming than the other methods. A great deal of effort is required to estimate the necessary input data and to keep this data up-to-date and internally consistent while the system or design is in a state of flux.

3. There is a potential difficulty in reviewing and evaluating cost models that use engineering relationships due to the size, complexity, and level of detail involved.

3.2.3 Analogy Cost Estimating Relationships

The analogy cost estimating relationships derive costs of new programs from data on past costs of similar programs. This technique frequently involves estimation of the incremental or marginal cost associated with program or equipment changes.

The advantages of the analogy type estimates are: they are relatively simple and inexpensive to performs; and they have reasonable accuracy for similar systems. Their disadvantages are: they require analogous equipments and data; they are limited to stable technology and may be limited to systems and equipment built by the same firm.

3.2.4 Subjective Cost Estimating Relationships

The subjective or judgmental cost estimating relationships are derived from "engineering judgment" of experts. The advantage of this type of CER is that it is available when there are insufficient data, parametric CER's or program definitions. Its disadvantages are: it's subject to bias; increased program complexity can quickly degrade the estimates; and the estimate cannot be substantiated or quantified.

3.3 Alternative Approach for Cost Modeling and Estimating

For some cost estimating of TRI-TAC programs, it will not always be feasible because of time and resource constraints to estimate the total life cycle costs for every proposed alternative hardware/software design or plan under consideration. There may be too many design alternatives to be costed. For these cases, an alternative approach which permits estimation of only the relative cost differences of the competing alternatives may be sufficient.

For these situations, cost elements are chosen from the cost breakdown structure of Figure 2 as in the general model. However, only those elements that are expected to vary from design alternative to design alternative are included in the cost model. One of the design alternatives is usually designated as a baseline. The cost elements of this design are costed in detail. Estimates are made for each element of each subsequent design alternative relative to these baseline elements. A positive value indicates that the respective element cost is higher than the baseline element cost. Costs are estimated in the same manner as the general model.

It should be recognized that the general model for estimating total life cycle costs for all alternatives is preferred. One reason is that the decision maker could be misled by the results of the relative cost analysis. For example, a relative cost difference of $1 million could be calculated. However, if a complete life cycle cost analysis has been performed, the actual costs of the alternatives could have been estimated as $100 million and $101 million. Thus, the $1 million difference might not be as significant as originally expected. Additionally, in using the relative cost difference approach, the analyst might have a tendency to leave out certain element costs because it looks as if there is no cost difference. A full-scale life cycle cost analysis might often show, however, that a significant difference exists.

4.0 METHODOLGY FOR LIFE CYCLE COST ANALYSIS

The previous sections have identified the general element structure and characteristics of a TRI-TAC Life Cycle Cost Model. This section presents a general methodology that should be followed in estimating life cycle costs for use in any cost analysis of joint tactical communication programs. Section 5 will present guidelines for the treatment of discounting, inflation, and the learning curve, which supplement the procedures of the model.

4.1 Introduction

The general methodology presented in this section was chosen to be applicable to all joint tactical communication life cycle costing exercises. Analysts should, however, tailor their life cycle costing methodology to be applicable to the specific analysis to be conducted for a particular TRI-TAC hardware or software.

A flowchart of the methodology is shown in Figure 14. The steps in the methodology are:

1. State study objectives.
2. Define assumptions
3. Select cost elements
4. Select cost estimating relationships
5. Collect data
6. Estimate element costs
7. Perform sensitivity analysis
8. Present results

The life cycle cost estimates are usually organized in tabular or graphical form to serve as inputs along with the results of system effectiveness analyses to cost-effectiveness studies. They are also useful as inputs to reports containing independent cost estimates and to many other kinds of management planning efforts.

The steps of the methodology are described in the following text.

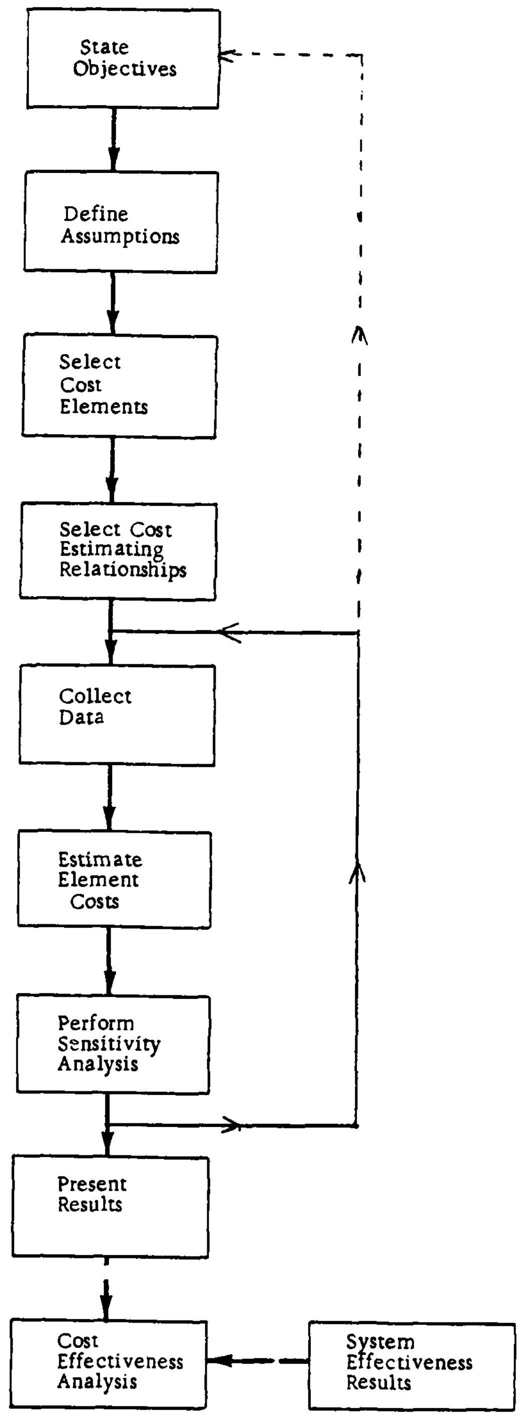

FIGURE 14
JOINT SERVICE LIFE CYCLE COSTING METHODOLOGY

4.2 State Study Objectives

The first step of the methodology is to identify, formulate, or state the objectives of the analysis or study which originally generated the need for the cost estimating exercise. The statement of the objectives is an important part of the analysis effort and might require updating and redefining following evaluation and feedback. Properly identified objectives will help to define and limit the scope of the cost analysis effort. This decision is often subjective and it could be heavily influenced by such factors as data inadequacies, schedule and manpower limitations, degree of accuracy required, amount of estimate rationale and justification required, uncertainties as to the appropriate method for modeling certain aspects of the problem. The analyst must rely on past experience gained through conducting and evaluating similar studies as well as a knowledge of the military environment and operation.

4.3 Define Assumptions

The adoption of valid assumptions that underlie the estimating process in life cycle costing is critical if the exercise is to yield useful results. Assumptions are often necessary to make the abstract cost model more representative of the proposed real world, because all specific detailed inputs are not always available, particularly for "far-out" systems.

It is imperative that every assumption be given a critical examination for its validity in a real world environment. A simplification of reality for the sake of model development might not accurately portray real world costs. On the other hand, the assumptions must be such as to not make the model too complex to be manageable. Generally, as the number and complexity of assumptions increase, the uncertainty associated with the conclusions reached in the analyses increases proportionately. The optimum balance lies somewhere in between. The model is only as complex as necessary to define important relationships. Most questions regarding the validity of a given model usually result from improper selection of assumptions.

Assumptions for joint tactical communication analyses usually fall into the following categories:

1. Procurement quantity
2. Rate of production
3. Concept of operation
4. Logistics support concept
5. Life of the equipment/system
6. Residual value

7. Disposal costs

8. Rate of Inflation

9. Rate of Discounting

10. Sunk Costs.

In the following discussion of each of the above categories, certain recommended factor/ground rules are presented which relate to TRI-TAC equipment and operation. These guidelines should be used unless more precise Service/Agency unique information is available. The intent is to obtain as much consistency as possible in the analysis of joint tactical communication systems/equipment, but not at the expense of accuracy. However, it must be reemphasized that TRI-TAC equipment are joint Service/Agency programs, and therefore, cost analyses efforts associated with these equipments must be conducted and the estimates must be prepared in the final analysis from a joint Service/Agency point of view. Stated differently, the cost element structure, model, and assumptions of this volume must be used by all Services/Agencies for estimating and analyzing costs of TRI-TAC equipment, architectural plans, etc.

Referring back to the list of assumptions, the procurement quantity specifies the total number of systems/equipments to be procured (e.g., world-wide minimum essential Service/Agency requirements including initial stock level, float pipeline, and training). The quantity specified must reflect as closely as possible the actual time-phased procurement intentions of the joint Service users. An invalid assumption will directly influence production and operating and support cost estimates. Recurring production costs will decrease as the number of units produced increases, and will exhibit the learning curve characteristics discussed in para. 5.3. Operating and support costs will vary with the procurement quantity since a greater number of systems/equipment fielded will necessitate a greater expenditure of resources.

The rate of production is the rate at which the system/equipment will be produced and delivered. This assumption has an impact on production, operating, and support costs. Non-recurring production costs are affected particularly in the area of tooling, production lines, and production facilities. The time-phased distribution of operating and support costs of fielded equipment depends upon the delivery schedule which in turn depends upon the rate of production assumptions.

The concept of operation describes the way a system/equipment is to be operated after deployment. Specifically, the analyst must describe the number, types, and skill levels of the personnel required for operation; consumables required; and the facility requirements. An operating/usage

factor of 8 hours/day, 365 days/year (i.e., 2920 hours/year) is recommended for most tactical equipment unless a more detailed analysis indicates otherwise. It is assumed that equipment for the DCS would be operated 24 hours/day, 365 days/year. Since the assumption on operating hours affects operating and support costs in a direct and significant way, it is important that the most accurate figure obtainable be used. Training plans should also be included, both in terms of on-the-job-training and formal proficiency training.

The logistics support concept describes among other things, how, where, and at what levels the equipment will be supported after deployment. The logistic support assumption should describe the numbers, types, and skill levels of the maintenance personnel; the facilities required; the repair strategies for the system/equipment; and stock level requirements. In the initial planning stages, the total logistics support like other portions of the system (e.g., training) concept is usually unknown. At this stage, a precise concept might not actually be required, but a simplified concept should be postulated. In subsequent life cycle cost iterations, the estimate and other criteria can aid the analyst in the selection of the optimum logistics support concept.

The life of the equipment can be specified in three ways. The physical life is the estimated number of years that the equipment can physically be used by the DOD in accomplishing the function for which it was procured. The technological life is the estimated number of years before technology will make the existing or proposed equipment obsolete. The preferred definition for the life of the equipment and the one that must be used in life cycle costing is the economic life. The economic life is the period of time over which the benefits to be gained from the equipment can reasonably be expected to accrue to the DOD. The economic life normally used for TRI-TAC life cycle cost analysis is ten years. This time period represents the economic life generally used by the military services in performing life cycle cost analysis of electronic equipment. It also represents the time period over which operating and support costs will be incurred.

The residual value represents any gain from the sale of the system/equipment at the end of its economic life. If the residual value is positive at this point in time, some of the resources expended for the system/equipment can be recovered through its sale. It should be noted that some cost analysis exercises involving TRI-TAC equipment will also include consideration of present inventory communications equipment. In these cases, residual value costs may become very important.

The disposal cost is the estimated cost that will be incurred in the disposal of the equipment at the end of its economic life. These costs might accrue through dismantling, selling, or scrapping the system/equipment. Since residual value is a positive value and disposal cost is a negative value, it is advantageous and realistic for most communications equipment to assume that they are equal. Therefore, these costs usually may be neglected, except where there is significant consideration of inventory equipment.

The effects of inflation are usually considered important in a life cycle cost analysis. Since the purchasing power of the dollar decreases with time, dollars spent in the present represent a greater purchasing power than those spent in the future. Therefore, if the analyst considers inflation, all costs incurred over time must be related to the value of the dollar in some base year. This can be accomplished through the use of the price index factors presented in para. 5.2. When inflation is not considered, a base year must still be specified. Then, all future costs will be expressed in "constant dollars", i.e., the value of the dollar in the base year.

Discounting is the process of finding the present value of a series of future cash flows. If discounting is appropriate to an analysis, the analyst should use the present DOD discount rate of ten percent. Para. 5.1 and Table 2 present a more detailed discussion of discounting, and identifies the circumstances under which discounting should be accomplished.

Sunk costs designate those costs irrevocably committed to a program.[1] Since sunk costs are already committed, there will be no variation for the costs between alternative systems or equipments. For comparative studies, only the relative cost differences of future expenditures are important. Thus, the analyst should exclude sunk costs from the analysis and concentrate on the future expenditures.

4.4 Select Cost Elements

The analyst should select cost elements as required for the specific analysis using the following guidelines:

1. All cost elements will be chosen from the standard TRI-TAC cost breakdown structure shown in Figure 2. This cost breakdown structure has been defined to standardize the definitions of cost elements for TRI-TAC related programs. The use of this cost breakdown structure will aid in the compilation of joint tactical communication costs for future analyses.

2. The analyst should select cost elements in as much detail as practicable for the cost model. Cost elements for sunk cost categories need not be considered.

3. There are times when costs cannot be broken out into separate cost elements. The analyst can estimate costs for the higher level cost category in this case. This estimate might be refined in later analyses when further information becomes available.

4.5 Select Cost Estimating Relationships

The procedure for estimating each cost element must be specified in this step. The analyst can select a parametric, an engineering,

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[1] In general this will include all previously expended costs, plus those costs contractually committed.

an analogy or subjective CER for the cost model. The availability of relevant data at the point in time when the analysis is conducted will influence this selection. As the acquisition process progresses, the mixture of cost estimating procedures selected for analysis will usually shift from the use of CER's to the use of actual costs. A number of CER's have been derived and are presented in Appendix B.

4.6 Collect Data

One of the greatest problems in estimating life cycle costs is the collection and validation of data. The data required for the analysis is often not available, particularly during the research and development phase. Even when data is available, it may be in a format unsuitable for the analysis at hand.

The analyst can avoid generating unnecessary work by determining whether adequate information is already available. The DOD Instruction 7041.3[1] suggests the following data sources: established reports, opinions and judgment of experts, observation and tabulation of steps in a work process, outside organization, and information centers.

The references of this volume[2] suggest possible data sources. The TRI-TAC Office has data available on personnel costs and some unit production costs of communications equipments. A further discussion of the problems of data collection and methods of treating the data problem can be found in G. H. Fisher's book, Cost Considerations in System Analysis. The LCC-3[3] document discusses possible DOD and service sources of operating and support data sources. Appendix E of the Army Electronics Command Pamphlet 11-4, Volume 7, documents several cost sources.

4.7 Estimate Element Costs

After the necessary input data has been collected and validated, estimates of element cost can be obtained through the use of relevant CER's. The analyst should also estimate the degree of cost uncertainty. This could be expressed statistically through confidence intervals or through pessimistic, most likely, or optimistic estimates. If a quantitative measure cannot be obtained, the analyst should make a qualitative judgment on the significance of the cost estimates. The presentation of the cost estimates is discussed in subsection 4.9.

4.8 Perform Sensitivity Analysis

The sensitivity analysis aids the analyst in determining uncertainty in life cycle cost estimates. All cost estimates should be examined for both validity of the inputs and the contribution of the element

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1/DOD Instruction 7041.3, Economic Analysis and Program Evaluation for Resource Management, October 18, 1972.

2/See list of references, Section 7.0.

3/DOD, Life Cycle Costing Guide for System Acquisition, LCC-3, January 1973.

cost to the total life cycle cost. The assessment of cost uncertainty in the previous step will assist the analyst in the sensitivity analysis by providing a measure of confidence in the element estimate. The element estimates representing a large percentage of the total cost estimate should be critically examined for accuracy. Additionally, the effects of the assumptions on the model outputs should be examined.

Basically, a sensitivity analysis is performed by systematically perturbing the inputs to the cost model and noting the effects on the output cost estimates. By doing this, the analyst is able to identify those portions of the cost estimate that require further refinement and to identify areas of risk.

Monte Carlo [1] methods can also be used in the evaluation of cost uncertainty. A Monte Carlo method is any procedure that involves statistical sampling techniques from a distribution of possible outcomes for obtaining a probabilistic approximation to the solution of a problem. Monte Carlo methods are most commonly employed when a great number of variables are present with inter-relationships so extremely complex as to forestall straight-forward analytical handling. This method usually involves the use of simulated data acquired by putting random numbers through transformations such that the data imitates significant aspects of the real world cost situation. The results of the Monte Carlo method applied to life cycle costing provide an estimate of the distribution of the life cycle cost. This distribution can be directly used in sensitivity analysis to identify the areas of risk.

A computational technique has been prepared by the TRI-TAC Office for dealing with cost uncertainty, which will assist in sensitivity analyses. The technique, which uses Monte Carlo methods, is available as a computer model and is described in Appendix G.[2]

4.9 Record and Publish Results of Cost Estimates

It is important that the steps followed in the analysis and the analysis results be adequately documented. This documentation should include:

1. A description of assumptions to include: R&D and production quantities and schedules; maintenance concepts; personnel requirements; and all other assumptions which are required to define the total cost to DOD of the system.

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[1] A discussion of the use of Monte Carlo methods in evaluating cost uncertainty can be found in Paul J. Dienemann's Estimating Cost Uncertainty Using Monte Carlo Methods, RAND Report 4854, The RAND Corporation, January 1966.

[2] TTO, Vol III, App. G.

2. Cost elements used and definitions unique to the system, subsystem, and/or equipment program costed.

3. Cost estimating relationships used, where they were taken from, their limitations, and the data base used.

4. A compilation of data/data sources.

5. Summary of element cost estimates and total life cycle cost estimates and the supporting material from which they were derived.

6. Inflation indices and how they were applied.

7. Description and results of sensitivity analyses.

5.0 DISCOUNTING, INFLATION AND THE LEARNING CURVE

This section discusses discounting, inflation, and the learning curve within the context of life cycle costing.

5.1 Discounting

The rationale behind discounting future cash flows is the realization that the deferral of expenditures allows the present use of money in alternative investments to yield some beneficial returns. If funds must be expended in the present, their use in alternative investments is lost. DOD Instruction 7041.3[1] prescribes the present DOD policy for the use of discounting (or present value analyses) for the economic analysis of DOD programs. At the present time the standard discount rate specified by DOD is ten percent per year compounded annually.

Discounting should be used for most economic analyses, with exceptions noted below. However, for all cost analyses of primary interest to decision makers in the acquisition of TRI-TAC programs, discounting can be omitted.

1. Decisions concerning the acquisition of commercial type services by Government or contractor operation.

2. Proposed programs/projects that if adopted would commit the DOD to a series of measurable costs that in aggregate would not extend over three years, or that result in a series of cash benefits that do not extend over three years from the inception date.

3. Program evaluation studies that deal only with historical costs and contain no cost comparisons.

Continuous discounting is to be used in economic analyses of joint tactical communications alternatives under study. The rationale for the use of continuous versus discrete discounting is essentially that the forecasted expenditures being treated are expected to occur at random throughout the identified time interval rather than being fully expended in a lump sum at the end of the interval. The continuous discount factor, for time interval t, and discount rate R, is calculated as follows:

$$\int_{t-1}^{t} (1 + R)^{-t} dt = \frac{R}{(1 + R)^{t} \ln (1 + R)}$$

The present value of any future cost can be obtained by multiplying that cost by the applicable discount factor. To assist the analyst, discount factors for 10% are shown for a twenty year period in Table 2.

[1] DOD, Economic Analysis and Program Evaluation for Resource Management, DOD Instruction 7041.3, 18 October 1972.

TABLE 2

ANNUAL DISCOUNT FACTORS

YEAR	10%
1	0.954
2	0.867
3	0.788
4	0.717
5	0.651
6	0.592
7	0.538
8	0.489
9	0.445
10	0.405
11	0.368
12	0.334
13	0.304
14	0.276
15	0.251
16	0.228
17	0.208
18	0.189
19	0.172
20	0.156

NOTE: These factors are equivalent to an arithmetic average of beginning and end of the year compound amount factors found in standard present value tables.

5.2 Inflation

The preparation of cost estimates for systems and programs involving the acquisition of major communications equipment should involve the consideration of economic escalation associated with the costs used in the estimate. It is the policy of the Department of Defense that all cost estimates for weapon systems will reflect the expected ultimate cost to acquire the system. All cost estimates should reflect the best estimate of the amounts ultimately to be paid specifically incorporating anticipated changes in future price levels; i.e., inflation. DOD Instruction 7041.3 gives the following guidelines for the treatment of inflation:

1. To assure consistency in comparative studies, all estimates of costs and financial benefits for each year of the planning period will first be made in terms of constant dollars; that is, in terms of the general purchasing power of the dollar at the time of decision. These estimates should not include any forecasted change in the general price level during the planning period.

a. Cost projections may be changed over the period of analysis to reflect only real changes in costs due to changes in amounts of services, for example, an increase in the amount of repair, or price changes in effect at the beginning of the period of analysis.

b. Cost projections may also be changed due to economies or diseconomies of scale resulting from an increase or decrease in the quantity of goods and services purchased.

2. When inflation is considered important to the conclusion of the study, a second computation will be made in terms of current (inflated) dollars. Using the constant dollar estimates as a baseline, inflation should then be included, by using the Office of the Assistant Secretary of Defense (OASD)(Comptroller) price indices for Procurement; Research, Development, Test and Engineering (RDT&E); Family Housing and Military Construction; Operations and Maintenance; and Military Personnel.

a. The only exception is when there are specific contractual arrangements. To avoid overestimating and double counting for the effects of inflation, consideration will be given to contract provisions which include provision for inflation, labor agreements, and the extent to which material is already on hand or will be furnished under fixed price contracts.

b. Table 3 gives OASD (Comptroller) price level indices for RDT&E, Procurement, Military Construction and O&S as of August 1979. Thus, the inflated value of any future expenditure can be obtained by multiplying that cost by the applicable price level index. When both discounting and inflation are performed, DOD Instruction 7041.3 suggests that the costs be first inflated, and then discounted.

TABLE 3

PRICE LEVEL INDICES (BASE YEAR FY 1981)

FY	RDT&E	PROCUREMENT	MILITARY CONSTRUCTION	O&M
78	78.65	78.15	77.15	78.22
79	85.41	84.95	84.56	85.34
80	92.42	92.25	92.34	92.25
81	100.00	100.00	100.00	100.00
82	107.70	108.00	107.60	107.80
83	115.45	116.10	115.35	115.35
84	122.96	123.88	122.96	122.84
85	129.72	130.69	130.34	129.60
Every Year Thereafter	5.5%	5.5%	6.0%	5.5%

SOURCE: OASD (COMPTROLLER)[1]
17 August 1979

NOTE: The latest OASD published indices should be used since the above figures are periodically updated. The analyst should also check the latest policy to determine what inflation indices are appropriate in life cycle cost analysis for O&S costs.

1/ASD Memo to AS of Army, Navy, Air Force, and Director of Defense Agencies, 17 August 1979, subject: Price Escalation Indices.

c. Lead Service frequently reissues the rates in Table 3 based on their research into the inflation occurring in specialized industries of particular importance to their programs. In the case of TRI-TAC programs, these special Service rates should be used in place of the OSD rates. However, the Lead Service has the responsibility of informing the other Services involved in their TRI-TAC Program as well as the TRI-TAC Office.

5.3 The Learning Curve

One of the assumptions needed to perform life cycle costing is production quantity. Sometimes the cost data collected on unit production costs do not correspond exactly to the production quantity to be used for the life cycle costing analysis. This section presents the theory regarding learning curves. It will allow the cost analyst to convert the collected data to the production cost needed for the analysis. (See Reference 11.)

The learning curve is based on historical evidence that as the total quantity of units produced increases, the man hours or cost to produce that quantity will be reduced by some percentage.

Some of the factor contributing to this decline are:

1. Repetition causes workers to become more familiar with the job.

2. Development of more efficient tools and machines.

3. Improvement in organization and management.

4. Solution of engineering production problems.

Figure 15 is an example of a learning curve plotted on recti-linear graph paper. However, when this same example is plotted on log-log paper, the curve becomes a straight line (Figure 16) and is referred to as "log-linear."

The general form of the equation for Figures 15 and 16 is:

$$Y = Ax^B \qquad (1)$$

where,

Y = cost for unit
A = the cost to produce the first unit
x = the cumulative output
B = the slope of the learning curve

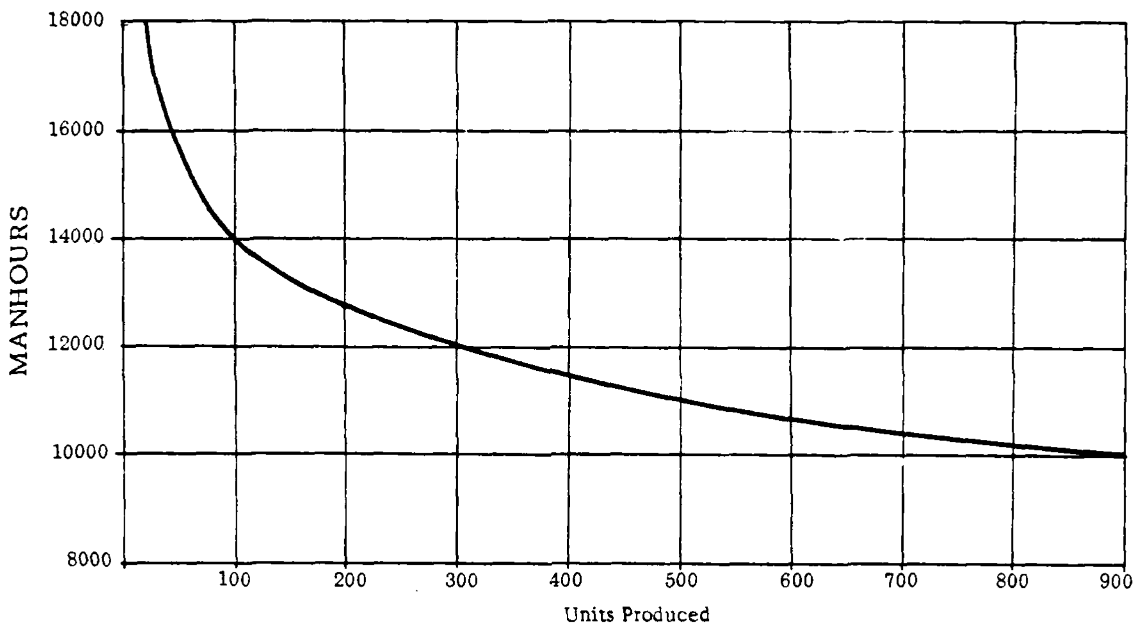

FIGURE 15
Learning Curve Example Plotted on Rectilinear Graph Paper

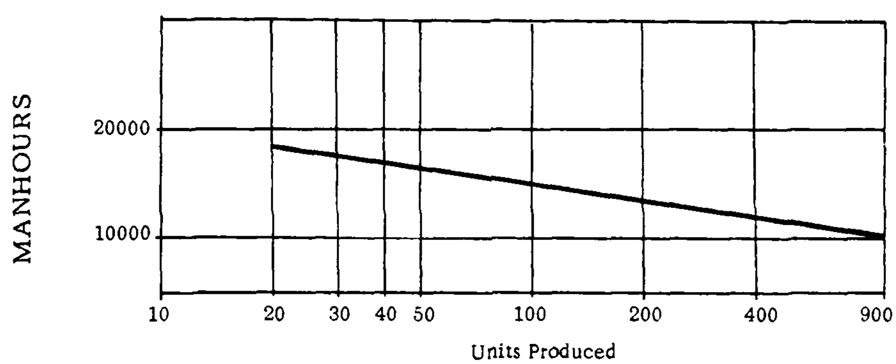

FIGURE 16
Learning Curve Example (From Figure 15)Plotted on Log-Log Paper

The production process may follow either a cumulative average or a unit log-linear curve. The analyst should recognize that both curves will not exhibit the "straight-line" characteristics at the same time. The relationship between the log-linear cumulative average curve and the resulting unit curve is illustrated by Figure 17. The relationship between the log-linear unit curve and the cumulative average curve is shown by Figure 18. It should be noted that the slope of the learnig curve varies b between different products, contractors, and even multiple production lines. Therefore, it is necessary that the analyst exercises due care in estimating these slopes and in application of the theory.

5.3.1 Cumulative Average Learning Curve

When an increased production quantity results in a constant percentage decline in the average cost, the cumulative average learning curve is described by:[1]

$$\overline{Y_n} = Ax^B \qquad (2)$$

where,

- $\overline{Y_n}$ = cumulative average cost of n items
- x = cumulative output
- A = cost of the first article
- B = slope of the learning curve (slope will be discussed in paragraph 5.3.3)

When the cumulative average learning curve is log-linear, the costs of individual units can be found from the relationship:[2]

$$y_i = A \left[x_i^{1 + B} - x_{i-1}^{1 + B} \right] \qquad (3)$$

where,

- y_i = cost per unit for the i^{th} unit
- x_i = cumulative unit number
- A = cost of the first article
- B = slope of the learning curve (slope will be discussed in paragraph 5.3.3)

1/Asher, Harold, Cost-Quantity Relationships in the Airframe Industry, The RAND Corporation, Report R-291, 1 July 1956, p. 18.

2/Ibid, p. 22.

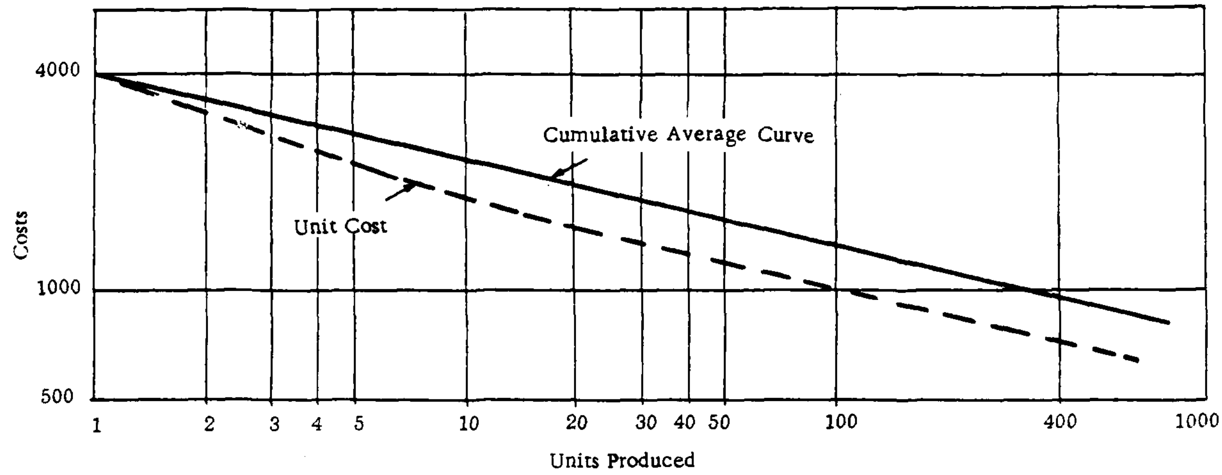

FIGURE 17
LOG-LINEAR CUMULATIVE AVERAGE CURVE

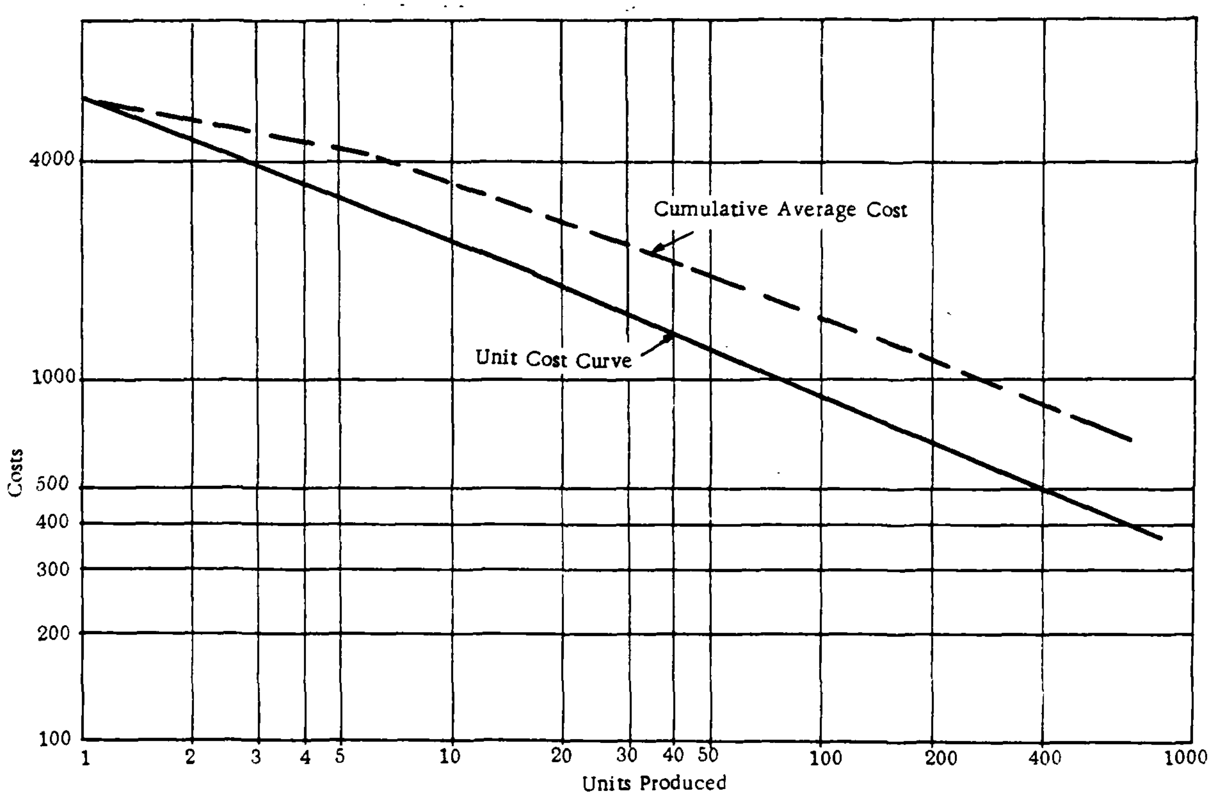

FIGURE 18
LOG-LINEAR UNIT COST CURVE

Figure 19 presents values of Equations (2) and (3) for selected production quantities and slopes when the value of A is equal to one. The unit cost values allow the analyst to find the unit cost for any combination of slope and production quantity listed, given the cost of some other production quantity listed. Similarly, the cumulative average cost values allow the analyst to find the cumulative average price for any combination of production quantity and slope listed, given the cost at some other listed production quantity. The ratio of cumulative average costs to unit costs is also given. The ratio can be used to quickly calculate the cumulative average cost or the unit cost when one or the other is known at a given quantity and price. Examples for the use of these values will be found in para. 5.3.4.1.

5.3.2 Unit Cost Learning Curve

When an increased production quantity results in a constant percentage decline in the unit cost, the unit cost learning curve is described by the function:[1]

$$y_i = A\,x_i^{B} \qquad (4)$$

where,

y_i = cost of the ith unit

x_i = cumulative output

A = cost of the first unit

B = slope of the learning curve.

When the unit cost learning curve is log-linear, the cumulative average cost can be found by the relationship:[2]

$$\bar{Y}_n = \frac{A \sum_{i=1}^{n} x_i^{B}}{n} \qquad (5)$$

where,

$\bar{Y}_n$ = cumulative average cost for n items

A = cost of first unit

x_i = cumulative output

B = slope of the learning curve.

Figure 20 presents values of Equations (4) and (5) for selected production quantities and slopes when A is equal to one. These values can be used to find the unit cost or cumulative average cost for selected production quantities and slopes. Para. 5.3.4 will present examples on the use of these values when the unit cost curve is log-linear.

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[1] Asher, p. 22.
[2] Ibid.

QUANTITY

SLOPE		2	5	10	25	50	100	250	500	1000	2000	5000
(y_i)	90%	0.800	0.675	0.602	0.521	0.469	0.421	0.366	0.330	0.297	0.267	0.232
	85%	0.700	0.538	0.452	0.362	0.307	0.260	0.210	0.178	0.152	0.129	0.104
	80%	0.600	0.418	0.329	0.242	0.193	0.154	0.115	0.0917	0.0734	0.0587	0.0435
$(\bar{Y}_n)$	90%	0.900	0.783	0.705	0.613	0.552	0.497	0.432	0.389	0.350	0.315	0.274
	85%	0.850	0.686	0.583	0.470	0.400	0.340	0.274	0.233	0.198	1.168	0.136
	80%	0.800	0.596	0.477	0.355	0.284	0.227	0.169	0.135	0.108	0.0866	0.0644
$(\frac{Yn}{yi})$	90%	1.13	1.16	1.17	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18
	85%	1.21	1.28	1.29	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.31
	80%	1.33	1.42	1.45	1.47	1.47	1.47	1.47	1.47	1.47	1.48	1.48

Where y_i = Cost per Unit for the i th unit

$\bar{Y}_n$ = Cumulative Average Cost of "n" items

$$y_i = \left[x_i^{1 + B} - x_{i-1}^{1 + B} \right] \qquad \bar{Y}_n = x^B$$

FIGURE 19

SLOPE - QUANTITY FACTORS FOR THE CUMULATIVE AVERAGE LEARNING CURVE

QUANTITY

	SLOPE	2	5	10	25	50	100	250	500	1000	2000	5000
	90%	0.900	0.763	0.705	0.613	0.552	0.497	0.432	0.389	0.350	0.315	0.274
(y_i)	85%	0.850	0.686	0.583	0.470	0.400	0.340	0.274	0.233	0.198	0.168	0.136
	80%	0.800	0.596	0.477	0.355	0.284	0.227	0.169	0.135	0.108	0.0866	0.0644
	90%	0.950	0.868	0.799	0.708	0.643	0.581	0.508	0.457	0.412	0.371	0.323
$(\bar{Y}_n)$	85%	0.925	0.806	0.712	0.592	0.510	0.438	0.355	0.303	0.258	0.219	0.178
	80%	0.900	0.747	0.632	0.492	0.402	0.327	0.246	0.198	0.159	0.127	0.0947
	90%	1.06	1.11	1.13	1.15	1.16	1.17	1.18	1.18	1.18	1.18	1.18
$\left(\frac{\bar{Y}_n}{y_i}\right)$	85%	1.09	1.17	1.22	1.26	1.28	1.29	1.30	1.30	1.30	1.30	1.31
	80%	1.13	1.25	1.32	1.39	1.42	1.44	1.46	1.47	1.47	1.47	1.47

where y_i = Cost per Unit for the i th Unit

$\bar{Y}_n$ = Cumulative Average Cost of "n" items.

$$y_i = x^B$$

$$Y_n = \frac{\sum_{1}^{n} x_i^B}{n}$$

FIGURE 20

SLOPE - QUANTITY FACTORS FOR THE UNIT COST LEARNING CURVE

5.3.3 Learning Curve Slope

The value of the learning curve slope, S, is defined as the ratio of Y values (either cumulative average cost or unit cost) at two x values (cumulative unit numbers) which differ by a factor of two. The slope may be expressed as:

$$S = \frac{\overline{Y}_{2x}}{\overline{Y}x} = \frac{A\ (2x)^B}{A\ (x)^B} \qquad (6)$$

or

$$S = 2^B. \qquad (7)$$

Slopes of 80 to 90 percent are most typical for the production programs for electronic equipments of interest to TRI-TAC. For an 80 percent slope, Equation (7) can be solved for B to yield a value of -0.322; similarly, solving Equation (7) for a slope of 90 percent gives B equal to -0.152. Table 4 presents values of B for slopes running from 75 to 90 percent. When the slope S is known, B can be found in the tables and substituted into one of the Equations (2), (3), (4) or (5).

5.3.4 Examples for the Use of the Learning Curve

This subsection presents examples for use of the log-linear cumulative average and the log linear unit cost curves.

5.3.4.1 Log-linear Cumulative Average Curve Example

Given:

(1) Unit Cost of 250th Unit = $5,000

(2) Slope of Cumulative Average Curves = 85% (B= -0.234)

Find:

(a) Cost of First Unit, A

(b) Cumulative Average Cost of the First 250 Units, $\overline{Y}_{250}$

(c) Total Cost of the First 250 Units

(d) Unit Cost of the 1000th Unit.

Solution:

(a) From Equation (3),

$$y_i = A\left[x_i^{\ 1+B} - x_{i-1}^{\ 1+B}\right]$$

TABLE 4

VALUES OF B FOR SLOPES BETWEEN 75 AND 90 PERCENT

SLOPE S	B
90	-0.152
89	-0.168
88	-0.184
87	-0.201
86	-0.218
85	-0.234
84	-0.252
83	-0.269
82	-0.286
81	-0.304
80	-0.322
79	-0.340
78	-0.358
77	-0.377
76	-0.396
75	-0.415

$$\therefore A = \frac{y_{250}}{\left[x_i^{\;1+B} - x_{i-1}^{\;1+B}\right]}$$

From Figure 15,

$$\left[x_i^{\;1+B} - x_{i-1}^{\;1+B}\right] = 0.210 = \frac{\$5,000}{0.210} = \underline{\underline{\$23,810}}$$

(b) Ratio $= \overline{Y}_n / y_i$

From Figure 15,

$$Y_{250}/y_{250} = 1.30$$

$$\therefore Y_{250} = 5,000\ (1.30) = \underline{\underline{\$6,500}}\ ^{1/}$$

Alternate solution:

From Equation (2),

$$\overline{Y}_n = Ax^B$$

From Figure 15,

$$x^B = 250^{(-.234)} = .274$$

$$\therefore Y_{250} = 23,810\ (.275) = \underline{\underline{\$6,548}}\ ^{1/}$$

(c) Total Cost of 250 units, T_{250}:

$$T_{250} = (250)\ \overline{Y}_{250} = (250)(\$6,548) = \underline{\underline{\$1,631,000}}$$

(d) Unit Cost of 1000th units,

$$y_i = A\left[x_i^{\;1+B} - x_{i-1}^{\;1+B}\right]$$

$$Y_{1000} = \$23,810\ (.152) = \underline{\underline{\$3,619}}$$

1/ Difference due to round off errors in Figure 19.

5.3.4.2 Log-Linear Unit Cost Curve Example

Given:

(1) Cumulative Average Cost of 50th Unit

$$\overline{Y}_{50} = \$5,000$$

(2) Slope of Log-linear Unit Cost Curve, S=90%

(B = -0.152)

Find:

(a) Cost of First Article A

(b) Cumulative Average Cost of the First 1500 Units

(c) Total Cost of 1500 Units

(d) Unit Cost of 1500th Unit

Solution:

(a) From Equation (5)

$$A = Y_{50} \left(\frac{n}{\sum x_i^{B}} \right)$$

But from Figure 16,

$$\frac{\sum_{i=1}^{n} x_i^{B}}{n} = .643$$

$$\therefore A = \frac{\$5,000}{.643} = \underline{\underline{\$7,776}}$$

(b)

$$\overline{Y}_{1500} = A \frac{\sum_{i=1}^{1500} x_i^{B}}{1500}$$ by substitution into Equation 5.

Interpolating between x = 1000 and x = 2000 in Figure 20.

$$\frac{\sum^{1500} x_i^{B}}{1500} \cong 0.392$$

$$\therefore \bar{Y}_{1500} \cong (\$7,776)(.392) = \underline{\underline{\$3,048}}$$

(c) The total cost of 1500 units T_{1500}:

$$T_{1500} = \bar{Y}_{1500}\ (1500)$$

$$\cong \$3,048\ (1,500) = \underline{\underline{\$4,572,000}}$$

(d) The unit cost of the 1500th unit can be found directly from Equation (4),

$$y_i = A\ x^B \quad \text{or}$$

$$y_{1500} = \$7,776\ (1,500)^{-0.152} = \underline{\underline{\$2,559}}$$

6.0 DESIGN TO COST

6.1 DTC Objectives

Design to Cost (DTC) is a management concept wherein rigorous cost goals are established during the development and the control of systems costs (acquisition, operating and support) to these goals is achieved by practical trade-offs between operational capability, performance, cost, and schedule. Cost, as a key design parameter, is addressed on a continuing basis and as an inherent part of the development and production process. The DOD objectives of the DTC concept, as given in DOD Directive 5000.28 are:

> "A. To establish cost as a parameter equal in importance with technical requirements and schedules throughout the design, development, production, and operation of weapon systems, subsystems, and components.
>
> B. To establish cost elements as management goals for acquisition managers and contractors to achieve the best balance between life cycle cost, acceptable performance, and schedule."

6.2 Developing the Design-to-Cost for TRI-TAC Programs

Whenever feasible, and as early in development as possible, DTC goals should be established for all elements of future life cycle costs of each TRI-TAC equipment program. These cost goals are to be related to hardware, software, and ILS proposed plans for all TRI-TAC programs. These planning goals include the Design to Unit Production Cost (DTUPC) goal and a Design to Unit Operation Cost (DTUOC) goal used in the validation contract. The DTUPC goal will be used for incentive and management control purposes for FSD and production. The overall initial planning goals, DTUPC and DTUOC, are defined for TRI-TAC purposes as the LCC DTC goal.

As the trade-off studies are conducted, the underlying objective is to drive this DTC lower by examination of alternative hardware/software designs, maintainability options, producibility considerations, reliability, and significant aspects of joint Service/Agency support and training.

In general, DODD 5000.28 requires that a program have only a single monetary DTC goal. This DTC goal is usually described as an average unit Flyaway Cost and is established by the Secretary of Defense for major programs and by a higher designated authority within each Service for less than major programs. The DTC goal for TRI-TAC programs should be estimated not later than entry into Full Scale Engineering Development. This goal is an in-house government goal established between the Service/Agency PM/SPO and the Secretary of Defense, is reviewed and concurred in by ASD (C^3I) and the TRI-TAC Office. It is the intent that, within the constraints of this official DTC goal,

the PM/SPO be given the authority to divide this goal into subgoals which in part will form the contractual development, DTUPC and O&S targets for the various contractors supporting the program. This overall planning DTC goal represents the government's estimate of affordability (cost to satisfy a DOD requirement) of the particular equipment program under consideration.

6.3 Relationship to DTC and DTUPC

The DTC goal is an average unit Flyaway Cost, a term related to the creation of a useable end item of hardware/software. Flyaway Cost includes all Procurement funded Non-recurring and Recurring costs, both contract and in-house, associated with the Work Breakdown Structure (WBS) elements of Major Systems Equipment (including installed Government Furnished Equipment except TRI-TAC equipment such as COMSEC or DGM), System/Project Management and System Test and Evaluation. The Flyaway Cost also includes an allowance for engineering changes, warranties, and first destination transportation, unless the latter is a separate budget line item. In the future, DTC goals may be applied to Operating and Support Costs.

A DTUPC goal is established as part of the contractual implementation of Design to Cost. The DTUPC goal can be viewed as a subgoal included within the DTC goal. It is that portion of the DTC over which the contractor has control and responsibility during design and development.

The DTUPC goal includes only the contractor portions of the DTC goal. DTC goals are established between the Service/Agency PM/SPO and the Secretary of Defense, and includes both contractor and government costs. It is vitally necessary that the contract contain DTUPC goals that include contractor furnished hardware elements and that the contractor take positive action to obtain equipment within the DTUPC goal and which makes proper contribution to achieving the DTC goal.

The DTUPC includes contractor Non-recurring and Recurring costs (including G&A and Fee/Profit) associated with the WBS elements of Major Systems Equipment (without GFE), System/Project Management, and System Test and Evaluation. The DTUPC does not include costs for GFE, training, data, peculiar support, operational site activations, or initial spares and repair parts.

6.3.1 DTUPC Description

In order to be an effective TRI-TAC management tool, a DTUPC should possess certain characteristics:

1. Precisely Defined - The identification of the items of the WBS with their complete description in terms of cost elements (expense activities) is essential. Figure 21 gives the production (non-recurring and recurring) cost elements that are normally associated with the DTUPC goals in the TRI-TAC program contracts. Not all the elements are used for every program, but the elements are designed to be flexible so that the PM/SPO can "tailor" the cost elements to the program's DTUPC goals.

PRODUCTION (Non-recurring)

Contractor (Non-recurring)

Prime Mission Equipment

Subsystems

System/Project Management

System Engineering
Project Management

System Test & Evaluation

PRODUCTION (Recurring)

Contractor (Recurring)

Prime Mission Equipment

Subsystems

System/Project Management

System Engineering
Project Management

System Test & Evaluation

NOTE: These cost elements and their subelements are normally included as part of the DTUPC goals for TRI-TAC Programs. G&A and Fee/Profit associated with these elemnts are also included.

FIGURE 21
PRODUCTION (NON-RECURRING & RECURRING) COST
ELEMENTS ASSOCIATED WITH DTUPC

2. Completely Described - This description is necessary to place the DTUPC in proper context for its management, tracking, and measurement. It involves fixing the values of the DTUPC to base parameters such as those listed below:

a. Type of dollars (constant dollar base year) in which the DTUPC is stated.

b. Quantity of units to be produced against which the DTUPC has been constructed.

c. The production rate and schedule considered.

d. Slope for the learning curve.

e. Other factors which may affect the DTUPC such as facilities for production, time frame for low rate initial production, and full-scale production.

3. Ceiling for DTUPC - The contract DTUPC should be regarded as a ceiling cost and included as such in the contract. This does not preclude the setting of additional lower goals, but the contract should specify an ultimae ceiling DTUPC representing the upper limit for cost. Contracts with DTUPC goals usually include incentives to motivate the contractor to meet the DTUPC goals.

4. Consistent Terms - The contract DTUPC should be established and stated in terms such that it is consistent over time. Minor ECP changes in the approved program should not effect the DTUPC, but a major program redirection will probably cause renegotiation of the DTUPC goals.

5. Flexibile - The contract DTUPC should have sufficient flexibility to accommodate cost trade-offs. Performance values or physical characteristics should be identified in terms of those which are subject to trade-offs and those which are not. Flexibility also needs to be applied to production areas such as materials or methods. If the strength of a component is a requirement, it should be so stated, but the materials and methods for its construction should be tradeable design options.

6. Trackable - The contract DTUPC should be trackable. This demans that the methods of tracking be a condition of the contract and implies that:

a. The development contractor has established cost budgeting, estimating, accounting, and reporting systems.

b. The status and progress against the DTUPC will be provided in specific cost element and WBS detail to the government at selected checkpoints of the development phase.

c. The Government has an approach for evaluating or validating the contractor's estimates of cost.

7. Measurable - The contract DTUPC should be measurable. At the end of development, the contractor will submit his final determination of the costs to produce the item. Since meeting the DTUPC will be a condition for the allowance of an award or incentive fee, the cost to produce (as claimed by the contractor at completion of development) must be measured against the DTUPC initially established. This involves an evaluation and audit by the Government to validate the cost claimed by the contractor and a procedure to adjust for intervening economic escalation, as well as Government-imposed changes.

6.4 Implementing Design-to-Cost

Up to this point, it should be clear that:

1. Establishing a DTC/LCC planning goal and specific contract DTUPC goals is not a simple task. The DTC/LCC concept is that a goal shall be established at program initiation or at the earliest practical date thereafter, but certainly not later than entry into full-scale development.

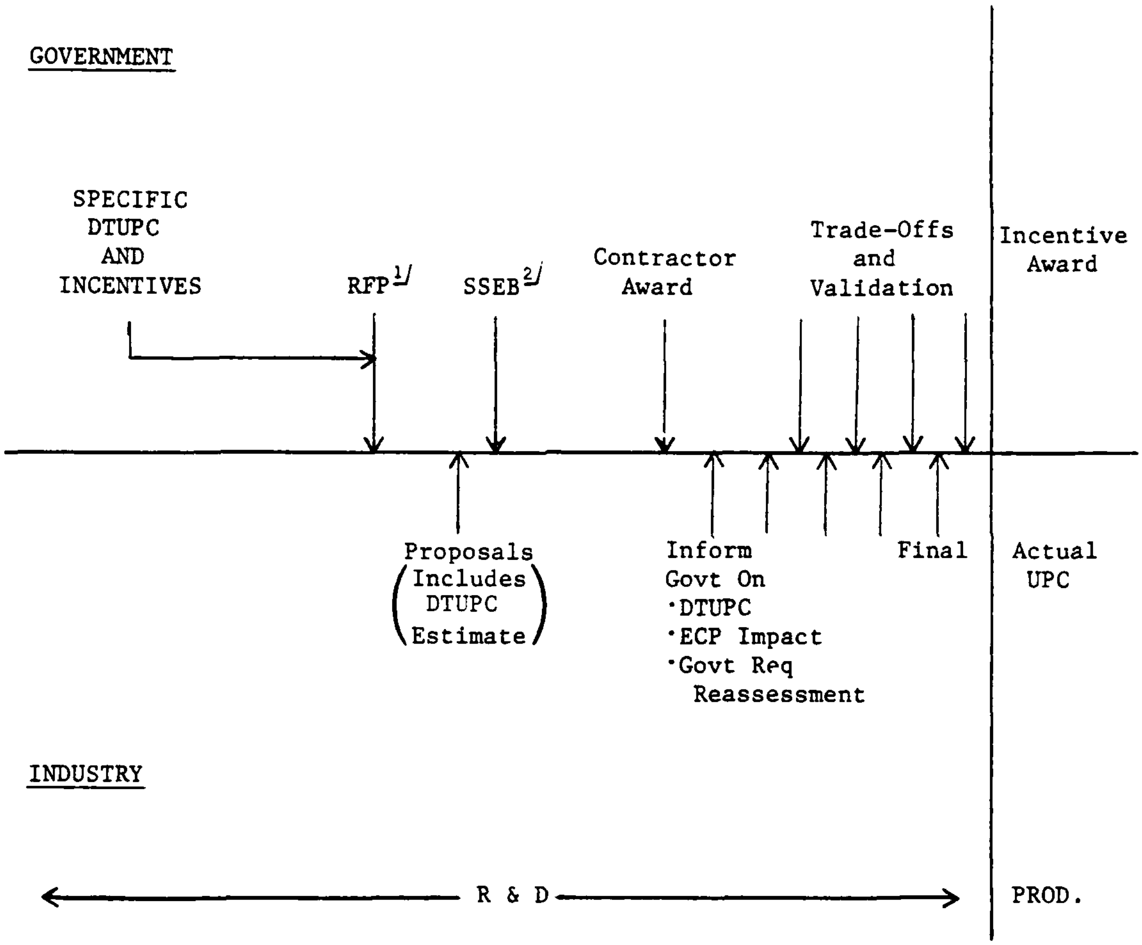
2. The DOD has made application of the DTC/LCC criteria mandatory on all programs where research and development costs are expected to be $75 million or greater, or where procurement costs are expected to be $300 million or greater. The DTC/LCC criteria has been applied to most TRI-TAC programs even though the research and development, and procurement costs are at lower levels than the DOD criteria.

3. Key elements of the DTC/LCC concept are the presence of competition during the development phase of a system and the use of incentive or award fees as inducements for successful development.

4. The phases of DTUPC are shown schematically in Figure 22. The Government will specify the government's DTUPC in the request for proposal (RFP) for the development contract. Competing developers' proposals would specify the contractor's DTUPC for his technical design and this would normally be less than or equal to the government goal.

5. As the development progresses, the contractors would be required to report on their progress toward developing a design that achieves the cost goal specified. Figure 23 illustrates this aspect of tracking the DTUPC showing progress toward the goal. If, in the tracking process, the goal appears unattainable, the total program would be reevaluated. The reevaluation could result in major program changes or cancellations of the program.

6. Portions of the incentive/award fee will normally be awarded in stages through the development period. At the completion of development, the Government must make a final validation of each developer's



[1] Request for Proposal
[2] Source Selection Evaluation Board

FIGURE 22
PHASES OF DESIGN TO UNIT PRODUCTION COST

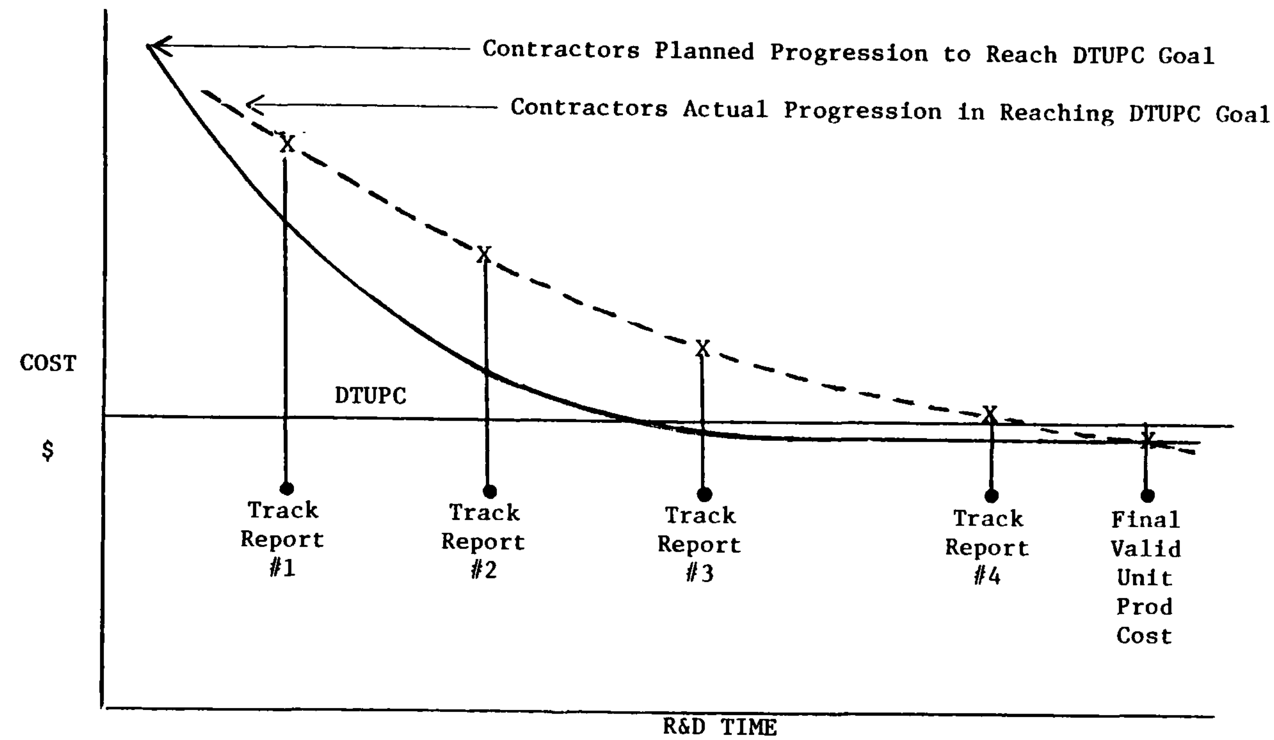


FIGURE 23
AN EXAMPLE OF DTUPC PROGRESSION

design and cost estimates to determine the success or degree of success each has demonstrated. The remaining incentive/award fee would be based on the results of this evaluation.

7. The application of the DTC concept has thus far been limited to production cost goals, i.e., DTUPC. But, the DTC concept is also applicable to operating and support costs. The application of specific "design-to" criteria for controlling operating and support costs has not yet been accomplished due to the lack of appropriate data base. However, efforts are underway to develop reliability, availability, and maintainability (RAM) data which will allow for the application of precise design-to-cost goals for operating and support costs.

6.5 Expectations from the DTUPC Concept

1. Some of the difficulties of establishing, tracking, and finally measuring attainment of the DTUPC have been presented and it is easy to see weaknesses. The DTUPC concept is only one tool for managing the development of weapon systems and should not be viewed in isolation. Life cycle cost remains the primary decision criteria used by the DSARC.

2. DTC and DTUPC for a program add new controls to the management process, and new dimensions to the principles of value engineering. Fears that DTC will result in the development and procurement of inferior weapon systems are rooted in a misunderstanding of the concept.

3. DTC technique was developed to implement the DOD weapons acquisition policy of making cost equal in priority to performance. The expectations from DTC can be stated as:

a. Maintain a stable production cost through the R&D phase.

b. Suppress "over design."

c. Improve the validity of resource planning for the production phase.

d. Insure the development of affordable weapon systems.

e. Insure a balance between schedule, performance, and production cost during the design phase of a system.

4. DTC is not a tool to control R&D cost, but it is a variable which impacts the cost of R&D. In fact, DTC may require additional research and development expenditures in order to reduce production and operating costs.

6.6 Weapon System Costs

Weapon System Costs (WSC) are an aggragate category of costs which have not been covered in the previous sections of this Volume. WSC's are important for DTC management and budgetory planning of procurement, and are particularly important to the TRI-TAC Office as representating an appropriate level for top management interest in monitoring periodic tracking reports. DTUPC reports deal only with specific contractor costs. The TRI-TAC programs include other costs significant to Service/Agency budgetory planning process, and therefore, a more inclusive cost aggregation is necessary.

Figure 24 presents a graphical summary of several aggregate categories of Procurement Costs as related to major Work Breakdown Structure Cost elements. The average unit Flyaway Cost is equivalent to the DTC. Weapon System Costs are obtained by adding to Flyaway Costs, Training, Peculiar Support Equipment, and Data, all of which are also under the control of the Service/Agency PM's/SPO's.

The TRI-TAC Office has requested the PM's/SPO's to report DTUPC's and WSC's at periodic program reviews and to explain methods used to obtain their estimates. Differences from the previous reported costs must also be described and the factors used for estimating Training must be explicitly shown. WS costs should provide an effective measure for monitoring PM/SPO budgetory progress for each TRI-TAC program.

	COST CATEGORY		APPROPRIATION	WORK BREAKDOWN STRUCTURE		
	PRODUCTION NON-REC	PRODUCTION REC	PROCUREMENT	MAJOR SYSTEM EQPT SYSTEM/PROJ MGMT SYSTEM TEST & EV	TRAINING PECULIAR SPT EQ DATA	INITIAL SPARES INITAL REPAIR PARTS
FLYAWAY COST	$	$	$	$		
WEAPON SYSTEM COST	$	$	$	$	$	
PROCUREMENT COST	$	$	$	$	$	$

FIGURE 24

WEAPON SYSTEM COSTS CATEGORIES

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8.0 GLOSSARY

Agencies	NSA, DCA
ASD	Assistant Secretary of Defense
BCE	Base Line Cost Estimates
CAIG	Cost Analysis Improvement Group
CDT	Contractor Development Test
CEPP	Cost Effectiveness Program Plan
CER	Cost Estimating Relationship
C^3I	Communications, Command, Control & Intelligence
DCP	Decision Coordinating Paper
DSARC	Defense Systems Acquisition Review Council
DTE	Development Test & Evaluation
DTC	Design to Cost
DTUPC	Design to Unit Production Cost
ECOM	U. S. Army Electronics Command
ECP	Engineering Change Proposal
ECU	Environmental Control Unit
FSD	Full Scale Development
GFE	Government Furnished Equipments
ICE	Independent Cost Estimate
ICP	Inventory Control Point
ILS	Integrated Logistic Support
IOTE	Initial Operational Test & Evaluation
IPCE	Independent Parametric Cost Estimates
IPF	Initial Production Facilities
LRIP	Low Rate Initial Production
LRU	Lowest/Line Replaceable Unit
MILCON	Military Construction
MIL-STD	Military Standards
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
OASD	Office of Assistant Secretary of Defense
ODP&E	Office of Director, Planning & Evaluation
O&S	Operating & Support
OTE	Operational Test & Evaluation
PATE	Production Acceptance Test & Evaluation
PCS	Permanent Change of Station
PEP	Producibility Engineering & Planning
PM/SPO	Program Managers/System Program Office
POL	Petroleum, Oil & Lubricants
R&D	Research & Development
RAM	Reliability, Availability & Maintainability
RDT&E	Research, Development Test & Engineering
RFP	Request for Proposal
Services	Army, Air Force, Navy, & Marine Corps
SSEB	Source Selection Evaluation Board
TRI-TAC	Joint Tactical Communications Office
ULS	Unit Level Switch

APPENDIX A

COST ELEMENT DEFINITIONS

This Appendix presents a detailed list of elements for life cycle costing.

APPENDIX A

COST ELEMENT DEFINITIONS

100 RESEARCH AND DEVELOPMENT - Research and Development costs include all the contractor and government non-recurring and recurring costs associated with the research, development, test and evaluation of the system/equipment hardware and software. Specifically, this covers all costs during the concept initiation, validation and full-scale development phases of the program. This category includes costs for feasibility, studies; simulation/modeling; engineering design, development, fabrication, assembly and test of and/or prototype engineering hardware models; initial system evaluation; associated documentation, and test of software. The costs incurred in this category culminate with the satisfactory completion of testing and subsequent acceptance by the government. This element is the summation of Cost Elements 110 and 120.

110 Concept and Validation

111 Contractor - The cost of any Concept Initiation and Validation work that may be performed under contract is considered in this element.

112 Government - The cost of any Concept Initiation and Validation work that may be performed by the Government is in this element.

120 Full Scale Development (FSD) - This element covers the total contractor and government non-recurring and recurring costs of FSD. FSD is that portion of the R&D phase in which a design concept, having been proven in theory (with/without the aid of simulation), is then engineered, fabricated and tested. It typically includes the program management, engineering, fabrication, testing, and associated documentation of the Prime Mission Equipment. This element is the summation of cost elements 121 and 122.

121 Full Scale Development (Non-recurring) - This element includes all the contractor and government non-recurring costs for FSD and is the sum of cost elements 122.1 and 123.1. These non-recurring costs are generally one-time costs incurred during the FSD phase, but these costs can recur if there is a change in design, contractor, or manufacturing process.

122.1 Contractor (Non-recurring) - The FSD (non-recurring) costs incurred by a private business while under contract with the Federal Government.

122.11 Prime Mission Equipment (PME) - This element refers to the development models of hardware and software used to accomplish the prime mission of the joint tactical communication program R&D on support equipment and services vital to the operations and maintenance of the communications equipment, but not integral with the prime function are excluded. When the prime mission equipment comprises several subelements of hardware and/or software or a mix of configurations, each should be listed separately beginning with 122.111. These elements include all efforts associated with

design and development of complete units (prototype and operationally configured units which satisfy the requirements of their applicable specifications). It also includes design and development for such items as interconnecting cabling and hardware.

122.12 System/Project Management - This refers to the systems engineering and technical control as well as the business management of particular systems/projects. Included are the planning, directing, and controlling of the definition and development of a system/project as well as logistic and logistic support, maintenance support, facilities, personnel and training, testing, and activities which might occur during R&D.

122.121 System Engineering - This element refers to the technical and management efforts of directing and controlling a totally integrated engineering effort of a system program. This element encompasses the systems engineering effort to define the system and the integrated planning and control of the technical program efforts of design engineering, logistic engineering, specialty engineering, production engineering for development and integrated test planning. This element includes but is not limited to: the system engineering effort to transform an operational need or statement of deficiency into a description of system requirements and a preferred system configuration; the R&D logistics engineering effort to define, optimize and integrate the logistics support considerations into the mainstream engineering effort to insure the future development and production of a supportable and cost effective joint tactical communications system; and the technical planning and control effort for planning, monitoring, measuring, evaluating, directing and replanning the management of the technical program. It excludes actual design engineering, and R&D production engineering directly related to the products or services of a deliverable R&D end item. (Examples of this element can be found in Reference 29, Section 7 of Volume III.)

122.122 Project Management - This refers to the business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall project objectives which are not associated with specific hardware elements and are not included in system engineering. (Examples of this element can be found in Reference 29, Section 7 of Volume III.)

122.13 System Test & Evaluation - This refers to the use of prototype, production, or specially fabricated hardware and/or software to obtain or validate engineering data on the performance of the electronics system. This includes detailed planning, conduct, support, data reduction and reports from such testing, and all hardware items which are consumed or planned to be consumed, in the conduct of such testing. It also includes all efforts associated with the design and production of models, specimens, fixtures, and instrumentation in support of the test program. Test articles which are complete units (i.e. functionally configured as required by the mission equipment) are excluded. Development, component acceptance, etc., testing which can be specifically associated with the hardware element, unless these tests are of special contractual or engineering significance (e.g., associate contractor) are also excluded.

122.131 Contractor Development Test This element refers to the activity conducted to: (a) demonstrate that the engineering design and development process is complete, (b) demonstrate that the design risks have been minimized, (c) demonstrate that the system will meet specifications, (d) estimate the system's military utility when introduced, (e) determine whether the engineering design is supportable (practical, maintainable, safe, etc.) for operational use, and (f) provide test data with which to examine and evaluate trade-offs against specification requirements, life cycle costs, and schedule. Contractor DT is planned and conducted by the contractor.

122.132 Mockups - The mockup element refers to the design engineering and production of systems or subsystem mockups which have special contractual or engineering significance, or which are not required solely for the conduct of one of the above elements of testing.

122.133 Test & Evaluation Support - This refers to all support elements necessary to operate and maintain systems and subsystems during testing and evaluation which are not consumed during a particular element of testing. Included, for example, repairable spares, repairs of repairables, repair parts, contractor technical support not allotable to a specific phase of testing. Operator and maintenance personnel, consumables, special fixtures, special instrumentation, etc., which are utilized and/or consumed in a single element of testing, and which should, therefore, be included under that element of testing are excluded.

122.134 Test Facilities - This refers to those special test facilities required for performance of the various developmental tests necessary to prove the design and reliability of the system or subsystem. This element includes, for example, white rooms, test chambers, etc. The brick-and-mortar-type facilities allotable to industrial facilities are excluded.

122.14 Training - This refers to training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will acquire sufficient concepts, skills, and aptitudes to operate and maintain the system with maximum efficiency. Included are all efforts associated with the design and development of training equipment as well as the execution of training services during R&D. Development costs associated with the equipment, services, and facilities, should be reported separately in 122.141, 122.142, and 122.143.

122.15 Peculiar Support Equipment - This refers to those items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which have applications peculiar to a given joint tactical communication item. This element includes, for example: vehicles, equipment, tools, etc., used to service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect or otherwise maintain the mission equipment during R&D. Also included is all effort associated with design, development, and production of development items of peculiar support equipment during R&D.

122.16 Data - This element refers to all deliverable R&D data required to be listed on a DD Form 1423. The data requirements will be selected from the TD-3. This element includes only such effort that can be reduced or will not be incurred if the data item is eliminated. If the data are government peculiar, include the efforts for acquiring, writing, assembling, reproduction, packaging and shipping. It also includes the effort for repreparing into government format with reproduction and shipment if data are identical to that used by the contractor, but in a different format.

122.161 Technical Orders Manuals - This element refers to those formal technical orders/manuals developed, as well as commercial, advance, real property installed equipment, and miscellaneous manuals for the installation, operation, maintenance, overhaul, training and reference of hardware/software, hardware systems and computer programs, and contractor instructional materials, inspection documentation, and historical type records that may accompany individual items of equipment. This element includes the data item descriptions set forth in functional category M of the TD-3.

122.162 Engineering Data - This refers to those engineering drawings, associated lists, specifications, and other documentation required by the government in accordance with functional categories E, H, R, S, & T of TD-3. Included, for example, are all plans, procedures, reports and documentation pertaining to system, subsystems, computer programs, component engineering, testing, human factors, analysis, etc.

122.163 Management Data - This refers to those data items necessary for configuration management, cost, schedule, contractual data management, program management, etc., required by the government in accordance with functional categories A, F, & P of TD-3. This element includes, for example, contractor cost reports, cost performance reports, contractor funds status reports, and schedule, milestone, networks, integrated support plans, etc.

122.164 Support Data - This element refers to those R&D data items designed to document the logistics support planning and provisioning process for the hardware in accordance with functional categories L and V of TD-3. Included, for example, are supply and general maintenance plans and reports, transportation, handling, packaging information, etc., and data to support the provisioning process.

122.165 Software Support Data - This element refers to those nonrecurring FSD costs of those data items required to develop and acquire a support capability for the computer software portion of the system. Included, for example, are the general plans for life cycle program maintenance, and any special handling procedures and data to support the software process. Also includes are software maintenance data, program listings, progress reports, training planning data, and trouble shooting procedures.

122.17 Other - This element includes all the other non-recurring costs incurred by the contractor during full scale development not included in the above listed elements. Contractor G&A and Fee can be detailed here

separately if necessary. Otherwise, it should be prorated among the preceeding elements in a manner compatible with contractor reporting.

123.1 Government (Non-recurring)

123.11 Program Management - This element includes the government's non-recurring FSD costs associated with the technical and administrative planning, organizing, directing, coordinating, controlling, and approval actions designed to accomplish overall program objectives during the R&D phase of the equipment life cycle. Examples of these activities are configuration management, cost/schedule management, data management, contract management, liaison, value engineering, quality assurance, and integrated logistic support management.

123.12 Test Site Activiation - This element includes the non-recurring FSD costs incurred to prepare a test site for government testing. It includes the cost of transportation of equipment and testing personnel to the test site. The cost of direct labor, material, overhead, and other direct charges is also included.

123.13 System Test & Evaluation (DTE/IOTE) - The Development Test and Evaluation (DTE) is designed to determine and/or verify technical performance and safety characteristics of an item, associated tools, and test equipment. It is conducted to: demonstrate that the engineering design and development process is complete; demonstrate that the design risks have been minimized; demonstrate that the systems will meet specifications; and estimate the system's utility when introduced. Initial Operational Test & Evaluation (IOTE) is that portion of Operational Test & Evaluation performed during the FSD Phase prior to a production decision. The objectives are to provide information at the production decision point as to the system/equipment military use, expected operational effectiveness, and operational suitability. This cost element includes the non-recurring FSD cost of direct labor, materials, overhead, and other direct charges incurred in the conduct of the DTE/IOTE. It also includes any Government costs in preparing test requirements, plans and procedures. Subdivide costs into DT and IOTE. Identify Joint Test Organization (JTO) cost separately. The Joint Test Element (JTE) of the JTO should be included in 123.11.

123.14 Government Furnished Equipment (GFE) - This is the non-recurring FSD cost to the Government of GFE supplied to the contractor during the full scale development phase of the equipment life cycle. Equipment loaned to a contractor and later returned to the Government in good condition may result in zero cost for this element if the cost of lost utility for the loaned equipment can be considered negligible. GFE (the quantity of which is not associated with the number of R&D items to be fabricated) that is to be integrated by the contractor into the subsystem or PME is costed in this element.

123.15 Training - This refers to training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will acquire sufficient concepts, skills, and

aptitudes to operate and maintain the system with maximum efficiency. This includes all effort associated with the design, development, and production of training equipment as well as the execution of training services.

123.16 <u>Other</u> - This element includes any other non-recurring FSD cost incurred by the Government during full scale development which is not included in the above elements.

124 <u>Full Scale Development (Recurring)</u> - This element includes all the contractor and government recurring costs for FSD and is the sum of cost elements 125.1 and 126.1.

125.1 <u>Contractor (Recurring)</u> - The FSD recurring costs incurred by a private business while under contract with the Federal Government.

125.11 <u>Prime Mission Equipment (PME)</u> - This element refers to the development of models of hardware and software used to accomplish the prime mission of the joint tactical communications equipment. When the prime mission equipment comprises several subelements of hardware and/or software or a mix of configurations, each should be listed separately beginning with 125.111. These elements include all efforts associated with the fabrication, integration, and assembly of complete R&D units. It also includes similar efforts for interconnecting cabling and hardware.

125.12 <u>System/Project Management</u> - This refers to the system engineering and technical control as well as the business management of particular systems/projects. Included are the planning/directing, and controlling of the R&D production.

125.13 <u>Initial Spares and Repair Parts</u> - This refers to the spare components or assemblies used for replacement purposes of major end items of equipment/software developed during R&D. Specifically included are development test spares.

126.1 <u>Government (Recurring)</u> - This element includes any costs that can be associated with the recurring FSD expenditures of the government.

126.11 <u>Government Furnished Equipment (GFE)</u> - This refers to the Recurring FSD costs to the Government of GFE supplied to the contractor during the full scale development phase of the equipment life cycle. These costs must be associated with the number of R&D items fabricated for test in order to be "Recurring."

126.12 <u>Initial Spares and Repair Parts</u> - This refers to the spare components or assemblies used for replacement purposes of GFE items of equipment/software for FSD.

200 PRODUCTION - This cost element is the total cost of Productions. It includes the non-recurring and recurring production costs of both the contractor and the government. It is the sum of cost elements 210 and 220.

210 Production (Non-recurring) - This cost element includes those program costs required beyond the development phase to introduce into operational use a new capability to procure initial, additional or replacement equipment for operational forces, or to provide for major modifications of an existing capability. Non-recurring costs refer to production costs which are one-time costs incurred during the production phase but these costs can recur if there is a change in design, contractor, or manufacturing process.

211.1 Contractor (Non-recurring) - The non-recurring production costs incurred by a private business while under contract with the Federal Government.

211.11 Prime Mission Equipment (PME) - This element refers to the hardware and software produced to accomplish the prime mission of the joint tactical communications program. Support equipment and services vital to the operation and maintenance of the communications equipment, but not integral with the prime function are excluded. When the prime mission equipment comprises several subelements of hardware and/or software or a mix of configurations, each should be listed separately beginning with 211.111. These elements include all efforts associated with non-recurring aspects of production, assembly, and integration of complete units (e.g. initial tooling costs). Also included are interconnecting cabling and hardware.

211.12 System/Project Management - This refers to the systems engineering and technical control as well as the business management of particular systems/projects. Included are the planning, directing, and controlling of the non-recurring aspects of the production of a system/project as well as logistic and logistic support maintenance, support facilities, personnel and training, testing, and activities during production. System engineering costs and project management costs should be reported separately in 211.121 and 211.122. Definitions of these are similar to 122.121 and 122.122 for development.

211.13 Training - This refers to training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will acquire sufficient concepts, skills, and aptitudes to operate and maintain the system with maximum efficienty. Included are all efforts associated with the production of training equipment as well as the execution of training services during the production of the prime mission hardware. Production costs associated with the equipment, services, and facilities should be reported separately in 211.131, 211.132, and 211.133.

211.14 Peculiar Support Equipment - This refers to those items required to support and maintain the system or portions o: the system which are not directly engaged in the performance of its mission, and which have

applications peculiar to a given joint tactical communications item. This element includes, for example, vehicles, equipment, tools, etc. used to service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain the mission during operation but not related to the quantity of mission items produced. Also included is all effort associated with production and sustaining engineering during production of peculiar support equipment.

211.15 Common Support Equipment - This refers to those fixed quantity items required to support and maintain the system or portions of the system, while not directly engaged in the performance of its mission, and which are presently in the DOD inventory for support of the systems. This element includes all efforts required to assure availability of this equipment for support of the particular joint tactical communications equipment. Also included is the non-recurring costs of the acquisition of additional quantities of these equipments if caused by the introduction of the TRI-TAC equipment into operational service.

211.16 Data - This refers to all deliverable data required to be listed on DD Form 1423. The data requirements will be selected from the TD3. This element includes only such effort that can be reduced or will not be incurred if the data item is eliminated. If the data are government peculiar, include the non-recurring efforts for acquiring, writing, assembling, reproducing, packaging, and shipping. It also includes the non-recurring effort for repreparing into government format with reproduction and shipment if data are identical to that used by the contractor, but in a different format. Subelements costs can be broken out, such as in 122.161-122.165.

211.161-165 Definitions similar to those for 122.161-165, except associated only with efforts during production.

211.17 Initial Spares and Repair Parts - This refers to spare components or assemblies used for replacement purposes in major end items of equipment. Only non-recurring costs, such as sustaining engineering involved with spares production, should be included.

211.18 System Test and Evaluation - This refers to the use, during production, of prototypes, production, or specially fabricated hardware to obtain or validate engineering data on the performance of the system. This includes the non-recurring costs associated with detailed planning, conduct, support, data reduction and reports from such testing, and all hardware items which are consumed, or planned to be consumed, in the conduct of such testing.

211.19 Software Center - This element represents the contractor non-recurring production costs incurred in establishing a software center for follow-on software support. The Software Center is a special purpose grouping of commercial, military, and special test equipment and software. It is configured so as to operate as a laboratory software development and test center and as a flexible program-preparation, program-validation, program-integration, and program-documentation center.

211.21 Other Contractor Non-recurring Costs - This element includes any contractor incurred non-recurring production costs not contained in the above cost elements.

212.1 Government (Non-recurring) - This element represents the government's non-recurring production costs.

212.11 Initial Training - This refers to initial training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which, say initial cadre personnel, will acquire sufficient concepts, skills, and aptitudes to operate and maintain the system with maximum efficiency, and aptitudes to train follow-on personnel. Government costs can be shown separated into 212.111, 212.112, and 212.113.

212.12 System Test and Evaluation (OTE) - This refers to government conducted testing and should be subdivided into 212.121 and 212.122. The costs incurred by the Joint Test Organization (JTO) should be identified. The Joint Test Element (JTE) of the JTO should be included in 212.13.

212.13 Program Management - This refers to government program office non-recurring costs associated with planning, directing, and controlling of the program.

212.14 Test Site Activation - This refers to the facility, equipment, and personnel expenses incurred in activating the test site.

212.15 Software Center - This element represents the government non-recurring production costs incurred in establishing a software center for follow-on software support. The Software Center is a special purpose grouping of commercial, military, and special test equipment and software. It is configured so as to operate as a laboratory software development and test center and as a flexibile progra-mpreparation, program-validation, program-integration, and program-documentation center.

212.16 Government Furnished Equipments (GFE) - This is the non-recurring production cost to the Government of GFE supplied to the contractor during the production phase of the equipment life cycle. Equipment loaned to a contractor and later returned to the Government in good condition may result in zero cost for this element if the cost of lost utility for the loan equipment can be considered negligible.

212.17 Common Support Equipment - Same as 211.15, only Government equipment.

212.18 Inventory Management - This cost element includes the non-recurring production costs of the management cost for entering an item in inventory. The costs include identification, description, submission to screening, and editing by Data Documents Center, inclusion in maintenance and supply catalogs, establishment by supply management of inventory and replacement rates, provisioning, requisitioning, rebuilding directions, and procurement directives. Annual recurring costs for maintaining an item in the inventory is costed in 322.31.

212.19 Other Non-recurring Production Costs - This element includes any other Government incurred non-recurring production costs not contained in the above cost elements.

220 PRODUCTION (RECURRING) - This cost element includes those production costs that recur with each unit produced. These costs tend to be subject to a learning curve concept in which the cost per unit decreases as quantity increases. The costs incurred in this category terminate with the satisfactory turnover of an operationally usable system to the using command or organization.

221.1 Contractor (Recurring) - The recurring production costs incurred by a private business while under contract with the Federal Government.

221.11-221.19 Military Standard 881A Definitions - See definitions provided in 211.1 only associted with contractor recurring expenses.

221.20 Other (Recurring) - This cost element includes any contractor incurred recurring production costs not contained in the above elements.

222.1 Government (Recurring) - This element includes those recurring investment costs incurred by organizations of the Federal Government.

222.11-222.15 Military Standard 881A Definitions - See definitions provided in 212.1 only associated with government recurring expenses.

222.16 Quality Control and Inspection - This element includes all Government recurring production costs associated with the quality control and inspection activities at the contractor's plant or at first destination.

222.17 Transportation - This element includes all the recurring production costs associated with the transportation, storage, and handling costs of the prime mission equipment from the point of procurement, production or testing to the user.

222.18 Operations Site Activities

222.19 Technical Orders and Manuals - This element covers the recurring production costs associated with the cost of assembly and publishing technical manuals/orders and other documents shipped with the equipment.

222.20 Government Furnished Equipments - This element includes the cost for any equipments/materials provided to a contractor for incorporation or integration into the end article being procured. An example of such material might be microcircuit chips for COMSEC equipment or the COMSEC equipment itself.

222.21 Support Engineering - All Government recurring production costs associated with the engineering performed after quantity production starts is included in this element. This will include such items as maintainability/reliability engineering, maintenance engineering, value engineering, and production engineering. This also includes the preparation, at depot level, for assuming the engineering function during the operating and support phase of the equipment life cycle.

222.22 Other (Recurring) - This includes any Government recurring production costs not included in the elements listed above.

300 OPERATING AND SUPPORT COSTS (O&S) - This category includes the costs of personnel, material, facilities and other direct and indirect costs required to operate, maintain and support the equipment/system during the operational phase. It includes the costs of all parts consumed in maintenance of the equipment as well as the costs of maintaining the necessary supply systems for parts, components, equipment and information.

310 Operations - This category includes costs associated with the use of the equipment. The costs incurred as a result of direct operation of the equipment and items actually consumed in the operation of the equipment are included in this category.

311 Energy Consumption - The cost of electrical power is the cost of battery, generator, or commercially supplied power required for the operation of the equipment.

312 Materials Consumption - This element covers the cost of materials consumed in the operation of the equipment. Examples of some typical items and materials are POL (petroleum, oil and lubricants), facsimile paper and paper rolls and paper tapes used with teletypewriter equipment.

313 Operator Personnel - This cost element is the manpower cost, direct and indirect, that is incurred in operating the equipment. Included within the determination of manpower cost is not only the cost of the operator's pay and allowances, but also the miscellaneous expenses, support costs, incentive and special pay, and replacement training costs. For presentation to the DSARC/CAIG this element will be used to account for Pay and Allowances. Other direct and indirect personnel costs will be accounted for under 330 and its subelements.

314 Operational Facilities - This element includes the annual maintenance of facilities used to house prime mission equipment. This includes maintenance of real property where applicable. All direct labor, material, overhead and other direct charges are included.

315 Equipment Leaseholds - This element includes costs for leasing special or peculiar equipment, devices, communication circuits, or material during the operating life cycle phase of the equipment/system.

316 Software Support - This element includes contractor and/or government costs for the computer software support required in the upkeep, modification or reprogramming of operational computer programs.

316.1 Software Personnel - This element is the manpower cost, direct and indirect, that is incurred in providing Software Support. Included within the manpower cost is not only the cost of each individual's pay and allowances, but also the miscellaneous expenses, support costs, incentive and special pay, and replacement training costs. For presentation of costs to the DSARC/CAIG this element will account for pay and allowances. Other personnel costs will be accounted for under 330 and its subelements.

316.2 Software Center - This element includes the annual upkeep of the Software Center (212.15). This includes maintenance of real property where applicable. All direct labor, material, overhead and other direct charges are included.

317 Other Operations Costs - This element includes other operations costs not included above. The following are examples of these possible costs:

- Operating Costs related to equipment shelters (i.e., heating and air conditioning).
- The cost of transportation of special materials from Central Supply locations/depots to the user if not included in the cost of the special material or under 322.5.
- Transportation costs of the prime mission equipment for purpose of operation (i.e., training exercises, deployments, etc.). For mobile tactical equipment, this basically involves POL for transporting vehicles.

320 Logistic Support - This element includes the cost of personnel, material, facilities and other direct and indirect costs required to maintain and support the equipment/system during the operational phase of its life cycle.

321 Maintenance - Maintenance includes all action taken to retain an end item in a serviceable condition or to restore it to serviceability. It includes inspection, testing, servicing, classification as to serviceability, repairs, overhaul, rebuilding, test and reclamation. Maintenance may be performed as a result of failure or in an attempt to increase the mean time between failure (MTBF) by use of scheduled preventive maintenance. Maintenance of the associated common and peculiar support equipment is also included.

321.1 Personnel - This cost element is the manpower cost, direct and indirect, that is incurred in the repair and preventive maintenance of the equipment. In the case of military personnel, it includes pay and allowances, miscellaneous expenses, support costs, incentive and special pay, and replacement training costs. In the case of civilian Government personnel, hourly rate factors are used. These hourly rate factors are corrected to account for overhead as well as general administrative costs. For presentation of costs to DSARC/CAIG, this element and 321.11, 321.12, 321.13 and 321.14 will be used to account for Pay and Allowances. Other personnel costs will be accounted for under 330 and its subelements.

321.11 Organizational Maintenance Personnel - This element includes that portion of the maintenance personnel costs associated with the organizational level of maintenance to include corrective and preventive maintenance. Organizational maintenance is that maintenance which is the responsibility of, and performed by, a using organization on its assigned equipment. Its phases normally consist of inspecting, servicing, lubricating, adjusting, and the replacement of parts, minor assemblies and subassemblies.

321.12 Intermediate Maintenance Personnel - This element includes that portion of maintenance personnel costs associated with the intermediate level of maintenance. Intermediate maintenance is that maintenance which is the responsibility of, and performed by, designated maintenance activities for support of using organizations. Its phases normally consist of calibration, repair or replacement of damaged or unserviceable parts, components or assemblies; the manufacture of critical non-available parts; and providing technical assistance to using organizations. Intermediate maintenance is normally accomplished in fixed or mobile shops, tenders, or shore based repair facilities, or by mobile teams.

321.13 Depot Maintenance Personnel (Scheduled Depot Overhaul) - This element includes that portion of maintenance personnel costs associated with the depot level maintenance. Depot maintenance is that maintenance which is the responsibility of, and performed by, designated maintenance activities, to augment stocks of serviceable material, and to support organizational maintenance and intermediate maintenance activities by the use of more extensive shop facilities, equipment and personnel of higher technical skill than are available at the lower levels of maintenance. Its phases normally consist of inspection, test, repair, modification, alteration, modernization, conversion, overhaul, reclamation, or rebuilding of parts, assemblies, subassemblies, components, equipment and items, and weapons systems; the manufacture of critical non-available parts; providing technical assistance to intermediate maintenance organizations and other activities. Depot maintenance is normally accomplished in fixed shops, shipyards and other shore based facilities, or by depot field teams. To simplify life cycle cost calculations, this element also includes the cost of material, depot overhead and other direct charges required to overhaul the equipment. Transportation of the prime mission equipment for the purpose of depot overhaul is accounted for under 322.5.

321.14 Depot Maintenance Personnel (LRU/Module Repair) - This element accounts for that portion of the depot maintenance personnel cost that can be associated with the repair of LRU/Modules at the depot.

321.2 Maintenance Facilities - This element includes the annual upkeep of facilities for maintenance. This includes upkeep of real property where applicable. All direct labor, material overhead and other direct charges are included.

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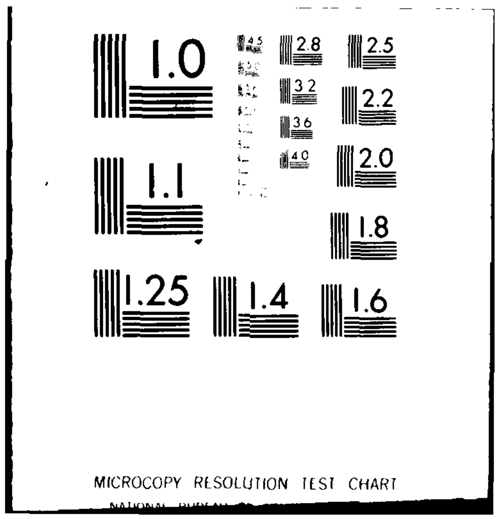
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321.3 Support Equipment Maintenance - This cost element includes the cost of maintenance and calibration of the common and peculiar support equipment.

321.4 Contractor Services - This element includes contractor costs for engineering and technical services and maintenance of the system/equipment. Contractor engineering and technical services include those services provided by commercial or industrial companies for advice, instruction and training to DOD personnel in the installation, operation, and maintenance of the equipment/system. Contract maintenance includes the cost incurred for maintenance of the equipment by commercial organizations on a one-time or continuing basis, without distinction as to the level of maintenance accomplished. All direct labor, material, overhead and other direct charges are included.

322 Supply - The supply function includes all the personnel, facilities, material, transportation and handling required to insure that all repair parts, consumables, and other required material are available at the repair site as required.

322.1 Personnel - This cost element is the manpower cost, direct and indirect, that is incurred in the supply function. Included is not only the cost of the personnel pay and allowances, but also the miscellaneous expenses, support costs, incentive and special pay, and replacement training costs. It includes the costs associated with the functions of packaging, preservation, receipt, transfer, issue and disposal of spares, repair parts, bulk materials, consumables and POL. For presentation of costs to DSARC/CAIG this element and 322.11, 322.12, and 322.13 will be used to account for Pay and Allowances. The other personnel costs will be accounted for under 330 and its subelements.

322.11 Organizational Supply Personnel - This element includes that portion of the supply personnel costs associated with the organizational level of supply. Material control personnel under the Chief of Maintenance are included herein.

322.12 Intermediate Supply Personnel - This element includes that portion of supply personnel costs associate with the intermediate level of supply. Base Supply personnel on an Air Base are included herein.

322.13 Depot Supply Personnel - This element includes that portion of the supply personnel costs associated with the depot level of supply if not included in 321.13.

322.2 Sustaining Investments - This is the cost of procuring replenishment spares, modification kits and material, and replacement of common support equipment.

322.21 Replenishment Spares and Repair Material - This cost element represents the cost of the repair parts, assemblies, consumables and other materials consumed in the maintenance process. This element is the sum of 322.211, 322.212, and 322.213. Initial spares and repair parts purchased during the investment phase are included in 210.19.

322.211 Organizational Level Spares - This cost element represents the cost of the spares, repair parts, assemblies, consumables and other materials consumed (if any) in the maintenance process at the organizational level of maintenance. Includes cost of replacement LRU's authorized for discard at the organizational level.

322.212 Intermediate/Depot Level Spares - This cost element represents the cost of the spares, repair parts, assemblies, consumables and other materials consumed in the maintenance process at the intermediate/depot level of maintenance. Includes cost of replacement LRU's authorized for discard at the intermediate and depot level of maintenance.

322.213 Repair Material - This element represents the cost of repair materials (piece parts, etc.) consumed in the repair of LRU's at the intermediate and depot levels of maintenance. It also includes the repair material consumed by the depot overhaul process if not costed by 321.13.

322.22 Modification - This element includes the cost of procuring the material associated with any official alteration made to the operating inventory equipment/system to make it safer for continued operation, enable it to perform mission essential tasks (not new capability) and to improve reliability or reduce maintenance costs. Included are the costs of fully developed and tested modification kits and spares plus the associated installation of these kits.

322.23 Replacement Common/Peculiar Support Equipment - This element includes the cost of replacing those common/ peculiar support equipments in the operating inventory that have failed. It also includes the cost of the item, transportation to user and any other direct charges associated with the item.

322.3 Inventory Administration - Inventory administration includes the cost of stocking inventory in the supply system as well as the functions of cataloging, provisioning and technically updating. Specifically, the cost is a function of inventory management, inventory holding, and technical data support.

322.31 Inventory Management - This cost element includes the annual management costs for maintaining an item in inventory.

322.32 Inventory Holding - Inventory holding is the cost of physically holding inventory in the supply system for one year. The factors included are: general storage cost, deterioration in storage, obsolescence, and losses in storage.

322.33 Technical Data Support - Includes the cost of updating the technical data and documents needed to perform maintenance on the system, its components, and support equipment.

322.4 Transportation - This cost element includes the transportation of spares, repair parts, failed/repaired items, and other repair material between organizational, intermediate and depot supply points (overseas and CONUS) in support of maintenance operations. Costs to transport the prime mission equipment for purpose of operation are included in 317. First and Second Destination transportation costs of the prime mission equipment are included in 221.14 and/or 222.12.

323 Other Logistic Support Costs - This element includes any logistic support costs not specifically included in the above listed elements. Maintenance and other logistic support of shelters, vehicles, ECU's, power generators, etc. may be included herein as appropriate.

330 Personnel Training and Support - This element includes the costs of replacement training, medical support, moving personnel and base support. For presentation of costs to DSARC/CAIG these costs have been extracted from 313, 316.1, 322.1 and their subelements.

331 Replacement Training - Includes the variable and fixed costs related to the accession, basic training, initial skill level training, and technical/specialized training of replacement personnel.

332 Health Care - Includes the variable cost of providing medical and dental support to military personnel.

333 Personnel Activities (PCS) - This element includes the permanent change of station (PCS) costs for the permanent relocation of personnel to and from overseas theaters and within CONUS.

334 Personnel Support - This element includes the cost of supplies, services, and equipment required to support the personnel that are operating, maintaining, and providing logistic support of the PME. Includes administrative supply items, custodial services, expendable office machines and equipment, etc.

335 Base Operating Support - This element includes the costs of real property management and accounts for the manpower, supplies, equipment, and facilities related to the performance of the base functions such as food services, supply, security, civil engineering, etc.

336.1 Transients, Patients, and Prisoners - Will be completed later.

APPENDIX B

FUNCTIONAL COST ELEMENTS

For very high cost or critical LCC elements, there may be a desire or a requirement to have more detailed data for analytical purposes. The following is the standard array for a functional cost breakdown of an LCC element. It is reported by industrial contractors through the Contractor Cost Data Reporting (CCDR) System and may, on occasion, be collected from in-house government facilities. Definitions for these functional costs are in Chapter 4 of the CCDR System Pamphlet, 5 November 1973.

<u>Engineering</u>
- Direct Labor Hours
- Direct Labor Dollars
- Overhead
- Material
- Other Direct Charges (Specify)
  - Total Engineering Dollars

<u>Tooling</u>
- Direct Labor Hours
- Direct Labor Dollars
- Overhead
- Materials and Purchased Tools
- Other Direct Charges (Specify)
  - Total Tooling Dollars

<u>Quality Control</u>
- Direct Labor Hours
- Direct Labor Dollars
- Overhead
- Other Direct Charges (Specify)
  - Total Quality Control Dollars

<u>Manufacturing</u>
- Direct Labor Hours
- Direct Labor Dollars
- Overhead
- Materials and Purchased Parts
- Other Direct Charges (Specify)
  - Total Manufacturing Dollars

Purchased Equipment
Material Overhead
Other Costs Not Shown Elsewhere (Specify)
Total Cost Less G&A
G&A
Total Cost Plus G&A
Fee or Profit

TOTAL

APPENDIX C

SAMPLE OPERATING AND SUPPORT COST ESTIMATING RELATIONSHIPS

This Appendix presents selected operating and support cost estimating relationships. The equations are keyed by number to the cost element definitions shown in Appendix A. Each equation has been set up to give the annual cost for that element.

The cost factors presented here provide a good starting point for estimating the O&S costs of a wide variety of tactical communication equipment. However, the cost factors should be reviewed for their validity at the time of their application.

The CER's presented in this Appendix have been structured into an automated computer model to assist the Services/Agencies perform rapid and consistent computation of Life Cycle Cost. The computer model is described in Appendix F to this Volume III (TTO-ORT-032-78B-V3-APF) dated June 1978.

311 Energy Consumption

Cost Formula

$$\begin{bmatrix}\text{Energy}\\ \text{Consumption}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Average}\\ \text{Elect. Power}\\ \text{Rating}\end{bmatrix} \times \begin{bmatrix}\text{Cost}\\ \text{Electrical}\\ \text{Power}\end{bmatrix} \times \begin{bmatrix}\text{Number of}\\ \text{Operating Hrs}\\ \text{Per Year}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix}$$

Cost Factors	Value	Units
Average Electrical Power Rating		KW
Cost of Electrical Power	0.04	$/KWH
Number of Operating Hours per Year	2920	Hours/Yr.
Quantity of Operational Equipment		Units

NOTE: $0.04 per KWH which is the cost of fuel to operate diesel generators equates to or slightly exceeds the price for commercial electricity costs.

312 Material Consumption

Cost Formula

$$\begin{bmatrix}\text{Material}\\ \text{Consumption}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Material}\\ \text{Consumption}\\ \text{Rate}\end{bmatrix} \times \begin{bmatrix}\text{Cost of}\\ \text{Consumable}\\ \text{Materials}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix}$$

Cost Factors	
Material Consumption Rate Per Unit	Variable (e.g. Pages/Yr, Rolls/Yr, etc.).
Cost of Consumable Materials	$/Page, $/Roll, etc.
Quantity of Operational Equipment	Units

313 **Operator Personnel**[1]

Cost Formula

$$\begin{bmatrix}\text{Operator}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Number of}\\ \text{Man-Hours}\\ \text{Per Operating}\\ \text{Hour}\end{bmatrix} \times \begin{bmatrix}\text{Cost of}\\ \text{Operator}\\ \text{Personnel}\end{bmatrix} \times \begin{bmatrix}\text{Number of}\\ \text{Operating}\\ \text{Hours Per}\\ \text{Year}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix}$$

Cost Factors	Value	Units
Number of Man-Hours Per Operating Hour		MH/OP.HR
Cost of Operator Personnel	[2]	$/HR
Number of Operating Hours Per Year	2920	Hours/YR
Quantity of Operational Equipment		Units

313 **Operator Personnel (Alternate)**[3]

Cost Formula

$$\begin{bmatrix}\text{Operator}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Annual Pay \&}\\ \text{Allowance of}\\ \text{Operators}\end{bmatrix} \times \begin{bmatrix}\text{Number of}\\ \text{Operators Required}\\ \text{Per Equipment}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix}$$

Cost Factors	Value	Units
Annual Pay and Allowance of Operators	[2]	$/YR/Person
Number of Operators Required Per Equipment		Number/Unit
Quantity of Operational Equipment		Units

[1] It should be determined whether or not the operator is required for the equipment or the equipment is incidental to the operator's mission. In the latter case, operator personnel cost should not be applied to the equipment cost. For example, in certain applications, equipment, such as telephones or facsimile equipment, may not require a dedicated operator.

[2] A separately bound Appendix D to this Volume III has been published (Jan 79) that provides guidance and tables on the calculations of military personnel costs.

[3] The alternate formula should be used to account for the base pay of operator personnel in BCE, IPCE & CAIG cost presentations.

321.1 <u>Maintenance Personnel</u>

Cost Formula

$$\begin{bmatrix}\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Organizational}\\\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Intermediate}\\\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Depot}\\\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix}$$

Cost Factors	Value	Units
Organizational Maintenance Personnel Cost	From 321.11	\$/Yr
Intermediate Maintenance Personnel Cost	From 321.12	\$/Yr
Depot Maintenance Personnel Cost	From 321.13	\$/Yr

321.11 <u>Organizational Maintenance Personnel</u>

Cost Formula

$$\begin{bmatrix}\text{Organizational}\\\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix} = \left[\begin{bmatrix}\text{Preventative}\\\text{Maintenance}\\\text{Time}\end{bmatrix} + \begin{bmatrix}\text{Corrective}\\\text{Maintenance}\\\text{Time}\end{bmatrix}\right] \times \begin{bmatrix}\text{Cost of}\\\text{Organizational}\\\text{Maintenance}\\\text{Personnel}\\\text{Per/Hour}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\\text{Operational}\\\text{Equipment}\end{bmatrix}$$

Where:

$$\begin{bmatrix}\text{Corrective}\\\text{Maintenance}\\\text{Time}\end{bmatrix} = \begin{bmatrix}\text{Number of}\\\text{Operating Hours}\\\text{Per Year}\end{bmatrix} \times \frac{\begin{bmatrix}\text{Mean Time}\\\text{To Repair}\end{bmatrix}}{\begin{bmatrix}\text{Mean Time}\\\text{Between Failures}\end{bmatrix}}$$

Cost Factors	Value	Units
Preventative Maintenance Time 2/		Hours/Yr.
Corrective Maintenance Time 2/		Hours/Yr.
Number of Operating Hours Per Year	2920	Hours/Yr.
Mean Time to Repair		Hours
Mean Time Between Failures		Hours
Cost of Organizational Maintenance Personnel Per Hour	1/	\$/Hours
Quantity of Operational Equipment		Units

1/A separately bound Appendix D to this Volume III has been published (Jan 1979) that provides guidance and tables on the calculation of military personnel costs.

2/Maintenance Time should be adjusted to include time required for documentation such as maintenance records and supply transaction records.

321.11 Organizational Maintenance Personnel (Alternate) [2]

Cost Formula

$$\begin{bmatrix}\text{Organizational}\\ \text{Maintenance}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Annual}\\ \text{Pay \&}\\ \text{Allowance of}\\ \text{Organizational}\\ \text{Maintenance}\\ \text{Personnel}\end{bmatrix} \times \begin{bmatrix}\text{Number of}\\ \text{Organizational}\\ \text{Maintenance}\\ \text{Personnel}\\ \text{Per Equipment}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Organizational}\\ \text{Equipments}\end{bmatrix}$$

Cost Factors	Value	Units
Annual Pay & Allowance of Organizational Maintenance Personnel	[1]	$/YR/Person
Number of Organizational Maintenance Personnel		Number/Unit
Quantity of Operational Equipment		Units

[1] A separately bound Appendix D to this Volume III has been published (Jan 1979) that provides guidance and tables on the calculation of military personnel costs.

[2] This CER accounts for the total Organizatonal Maintenance Pay & Allowance costs and is suitable for budgetary type estimates, base line cost estimates and independent parametric cost estimates where the equipment parameters of MTBF, MTTR are not considered in estimating personnel costs.

321.12 Intermediate Maintenance Personnel (LRU/Module Repairs)

Cost Formula

$$\begin{bmatrix}\text{Intermediate}\\ \text{Maintenance}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} = \frac{\begin{bmatrix}\text{Operating}\\ \text{Hours}\\ \text{Per Year}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix}}{\begin{bmatrix}\text{Mean Time}\\ \text{Between Failures}\end{bmatrix}} \times \begin{bmatrix}\text{Percent of all Failed}\\ \text{Modules to be}\\ \text{Repaired/Discarded}\\ \text{at Intermediate Level}\end{bmatrix}$$

$$\times \begin{bmatrix}\text{Module}\\ \text{Mean Time}\\ \text{To Repair}\end{bmatrix} \times \begin{bmatrix}\text{Cost of}\\ \text{Intermediate}\\ \text{Maintenance}\\ \text{Personnel}\\ \text{Per Hour}\end{bmatrix}$$

Cost Factors	Value	Units
Operating Hours Per Year	2920	Hours/YR
Quantity of Operational Equipment		Units
Mean Time Between Failures (MTBF)		Hours
Percent of Failed Modules Discarded/Repaired		Percent
Module Mean Time To Repair (MTTR)		Hours
Cost of Intermediate Maintenance Personnel per Hour	[1]	$/Hour

321.12 Intermediate Maintenance Personnel (LRU/Module Repairs) (Alternate)[2]

Cost Formula

$$\begin{bmatrix}\text{Intermediate}\\ \text{Maintenance}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Annual Pay \&}\\ \text{Allowance of}\\ \text{Intermediate}\\ \text{Maintenance}\\ \text{Personnel}\end{bmatrix} \times \begin{bmatrix}\text{Number of}\\ \text{Intermediate}\\ \text{Maintenance}\\ \text{Personnel Per}\\ \text{Equipment}\end{bmatrix}^{3/} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipments}\end{bmatrix}^{4/}$$

Cost Factors	Value	Units
Annual Pay & Allowance of Intermediate Maintenance Personnel		$/YR/Person
Number of Intermediate Maintenance Personnel[3]		Number/Unit
Quantity of Operational Equipments[4]		Units

[1] A separately bound Appendix D to this Volume III has been published (Jan 79) that provides guidance and tables on the calculation of military personnel costs.

[2] This CER accounts for the total pay & allowances of intermediate maintenance personnel and is suitable for budgetary type estimates, base line cost estimates and independent parametric cost estimates where the equipment parameters of MTBF, MTTR are not considered in estimating personnel costs.

[3] Could also be personnel required per intermediate maintenance site/ facility in which,

[4] Would be Quantity of intermediate maintenance sites/facilities.

321.13 Depot Maintenance Personnel

Cost Formula

$$\begin{bmatrix}\text{Depot}\\\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix} \quad \begin{bmatrix}\text{Annual Cost}\\\text{of Depot}\\\text{Maintenance}\\\text{Personnel}\end{bmatrix} \quad \begin{bmatrix}\text{Number of}\\\text{Depot}\\\text{Maintenance}\\\text{Personnel}\end{bmatrix}$$

Cost Factors	Value	Units
Annual Cost of Depot Maintenance Personnel		\$/YR/Person
Number of Personnel		Number

321.14 Depot Maintenance Personnel (LRU/Module Repairs)

Cost Formula

$$\begin{bmatrix}\text{Depot}\\\text{Maintenance}\\\text{Personnel}\\\text{Cost}\end{bmatrix} = \frac{\begin{bmatrix}\text{Operating}\\\text{Hours}\\\text{Per Year}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\\text{Operational}\\\text{Equipment}\end{bmatrix}}{\begin{bmatrix}\text{Mean Time}\\\text{Between Failures}\end{bmatrix}} \times \begin{bmatrix}\text{Percent of all Failed}\\\text{Modules to be}\\\text{Repaired/Discarded}\\\text{at Depot Level}\end{bmatrix}$$

$$\times \begin{bmatrix}\text{Module}\\\text{Mean Time}\\\text{To Repair}\end{bmatrix} \times \begin{bmatrix}\text{Cost of}\\\text{Depot}\\\text{Maintenance}\\\text{Personnel}\\\text{Per Hour}\end{bmatrix}$$

Cost Factors	Value	Units
Operating Hours Per Year	2920	Hours/YR
Quantity of Operational Equipment		Units
Mean Time Between Failures (MTBF)		Hours
Percent of Failed Modules Repaired/Discarded		Percent
Module Mean Time to Repair (MTTR)		Hours
Cost of Depot Maintenance Personnel per Hour		\$/Hour

321.3 Support Equipment Maintenance

Cost Formula

$$\begin{bmatrix}\text{Support}\\ \text{Equipment}\\ \text{Maintenance}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Support}\\ \text{Equipment}\\ \text{Maintenance}\\ \text{Factor}\end{bmatrix} \times \begin{bmatrix}\text{Cost of Common and}\\ \text{Peculiar Support}\\ \text{Equipment}\end{bmatrix}$$

Cost Factors	Value	Units
Support Equipment Maintenance Factor	10%	Percent
Cost of Common and Peculiar Support Equipment	From 211.14/15 and 221.13/14	$

322.1 Supply Personnel

Cost Formula

$$\begin{bmatrix}\text{Supply}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Organizational}\\ \text{Supply}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Intermediate}\\ \text{Supply}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Depot}\\ \text{Supply}\\ \text{Personnel}\\ \text{Cost}\end{bmatrix}$$

Cost Factors	Value	Units
Organizational Supply Personnel Cost	From 322.11	$/YR
Intermediate Supply Personnel Cost	From 322.12	$/YR
Depot Supply Personnel Cost	1/	

1/ For ease of calculation, it can be assumed that Equation 321.13 which calculates the cost of depot overhaul, includes the depot supply personnel costs in the overhead rates of the maintenance personnel.

322.11 Organizational Supply Personnel

Cost Formula

$$\begin{bmatrix}\text{Organizational}\\ \text{Supply}\\ \text{Personnel Cost}\end{bmatrix} = 0.03 \begin{bmatrix}\text{Organizational}\\ \text{Maintenance}\\ \text{Personnel Cost}\end{bmatrix}$$

Cost Factors	Value	Units
Organizational Maintenance Personnel Cost	From 321.11	$/YR

322.12 Intermediate Supply Personnel

Cost Formula

$$\begin{bmatrix}\text{Intermediate}\\ \text{Supply}\\ \text{Personnel Cost}\end{bmatrix} = 0.03 \begin{bmatrix}\text{Intermediate}\\ \text{Maintenance}\\ \text{Personnel Cost}\end{bmatrix}$$

Cost Factors	Value	Units
Intermediate Maintenance Personnel Cost	From 321.12	$/YR

322.21 Replenishment Spares & Repair Material

Cost Formula

$$\begin{bmatrix}\text{Replenishment}\\ \text{Spares and}\\ \text{Repair Material}\end{bmatrix} = \begin{bmatrix}\text{Inventory}\\ \text{Replenishment}\\ \text{Cost Factor}\end{bmatrix} \times \begin{bmatrix}\text{Equipment}\\ \text{Unit}\\ \text{Production}\\ \text{Cost}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix}$$

Cost Factors	Value	Units
Inventory Replenishment Cost Factor	5%	Percent/YR
Equipment Unit Production Cost		$/Unit
Quantity of Operational Equipment		Units

322.21 Replenishment Spares and Repair Material (Alternate)

Cost Formula

$$\begin{bmatrix}\text{Spare Parts}\\ \text{and Repair}\\ \text{Material}\end{bmatrix} = \begin{bmatrix}\text{Organizational}\\ \text{Maintenance}\\ \text{Spares Cost}\end{bmatrix} + \begin{bmatrix}\text{Intermediate/Depot}\\ \text{Maintenance}\\ \text{Spares Cost}\end{bmatrix} + \begin{bmatrix}\text{Repair}\\ \text{Material}\\ \text{Cost}\end{bmatrix}$$

Where:

(EQN. A)

$$\begin{bmatrix}\text{Organizational}\\ \text{Maintenance}\\ \text{Spares Cost}\end{bmatrix} = \frac{\begin{bmatrix}\text{Operating}\\ \text{Hours}\\ \text{Per Year}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix} \times \begin{bmatrix}\text{Average Cost}\\ \text{of Discarded}\\ \text{Modules}\end{bmatrix}}{\begin{bmatrix}\text{Mean Time Between Failures of}\\ \text{Discarded Modules}\end{bmatrix}}$$

(EQN. B)

$$\begin{bmatrix}\text{Intermediate/}\\ \text{Depot}\\ \text{Maintenance}\\ \text{Spares Cost}\end{bmatrix} = \frac{\begin{bmatrix}\text{Operating}\\ \text{Hours}\\ \text{Per Year}\end{bmatrix} \times \begin{bmatrix}\text{Quantity of}\\ \text{Operational}\\ \text{Equipment}\end{bmatrix} \times \begin{bmatrix}\text{Average Cost}\\ \text{of Repairable}\\ \text{Modules}\end{bmatrix} \times \begin{bmatrix}\text{1/}\end{bmatrix}}{\begin{bmatrix}\text{Mean Time Between Failures of}\\ \text{Repairable Modules}\end{bmatrix}}$$

(EQN. C)

$$\begin{bmatrix}\text{Repair}\\ \text{Material}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Repair}\\ \text{Material}\\ \text{Rate}\end{bmatrix} \times \begin{bmatrix}\text{EQN. B}\end{bmatrix}$$

Cost Factors	Value	Units
Operating Hours per Year	2920	Hours/YR
Quantity of Operational Equipment		Units
Average Cost of Discarded Modules		$
Mean Time Between Failures of Discarded Modules		HRS
Average Cost of Repairable Modules		$
Mean Time Between Failures of Repairable Modules		HRS
Discard Rate	15%	Percent
Repair Material Rate	5%	Percent

1/ For EQN. B use $\begin{bmatrix}\text{Discard Rate}\end{bmatrix}$

For EQN. C use $\begin{bmatrix}\text{1 - Discard Rate}\end{bmatrix}$

322.3 Inventory Administration

Cost Formula

$$\begin{bmatrix}\text{Inventory}\\ \text{Administration}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Inventory}\\ \text{Management}\\ \text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Inventory}\\ \text{Holding}\\ \text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Technical}\\ \text{Data}\\ \text{Support}\\ \text{Cost}\end{bmatrix}$$

Cost Factors	Value	Units
Inventory Management Cost	From 322.31	\$/YR
Inventory Holding Cost	From 322.32	\$/YR
Technical Data Support Cost	From 322.33	\$/YR

322.31 Inventory Management

Cost Formula

$$\begin{bmatrix}\text{Inventory}\\ \text{Management}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Number of}\\ \text{New FSN}\\ \text{Items}\end{bmatrix} \times \frac{\begin{bmatrix}\text{1st Year}\\ \text{Recurring}\\ \text{Cost}\end{bmatrix} + \begin{bmatrix}\text{Annual}\\ \text{Recurring}\\ \text{Cost}\end{bmatrix} \times \begin{bmatrix}\text{Number of}\\ \text{Years per} -1\\ \text{Life Cycle}\end{bmatrix}}{\begin{bmatrix}\text{Number of Years}\\ \text{Per Life Cycle}\end{bmatrix}}$$

Cost Factors	Value	Units
Number of New FSN Items		Items
1st Year Recurring Cost	From Chart Below	\$/Items
Annual Recurring Cost	From Chart Below	\$/Item/Year
Number of Years Per Life Cycle	10	Years

INVENTORY LINE ITEM MANAGEMENT COSTS

FSN Dollar Value	Introduction Costs [1]	First Year Recurring Cost	Annual Recurring Costs
Over - \$500,000	\$306	\$1,489	\$1,489
\$50,000 - \$500,000	306	918	918
\$ 5,000 - \$ 49,999	306	326	326
Under - \$ 5,000	306	236	236

[1] These costs are accounted for under 212.18.

322.32 Inventory Distribution/Holding

Cost Formula

$$\begin{bmatrix}\text{Inventory}\\ \text{Holding}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Inventory}\\ \text{Distribution/}\\ \text{Holding}\\ \text{Cost Factor}\end{bmatrix} \times \begin{bmatrix}\text{Average Dollar}\\ \text{Value of Total}\\ \text{Spares in Storage}\\ \text{Over the Life}\\ \text{Cycle}\end{bmatrix}$$

Cost Factors	Value	Units
Inventory Distribution/Holding Cost Factor	3%	Percent
Average Dollar Value of Total Spares In Storage over the Life Cycle	1/	$/Yr

Comment

Inventory Holding is the cost of holding inventory in the supply system for one year, which involves the measurement of storage costs, and other losses. The 3% is made up of the following factors:

Other Losses	2 Percent
Storage Costs	1 Percent
Total	3 Percent

1/ The average dollar value of total spares in storage considers the average value of both the initial spares purchased during the production contract and the replenishment of spares used during the life cycle.

322.33 Technical Data Support Cost

Cost Formula

$$\begin{bmatrix}\text{Technical}\\ \text{Data}\\ \text{Support}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Technical}\\ \text{Data}\\ \text{Pages}\\ \text{Requiring}\\ \text{Revision}\end{bmatrix} \times \begin{bmatrix}\text{Technical}\\ \text{Data}\\ \text{Management}\\ \text{Costs}\end{bmatrix}$$

Cost Factors	Value	Units
Number of Technical Data Pages Requiring Revisions		Pages/Yr
Technical Data Management Cost		$/Page

322.5 Transportation

Cost Formula

$$\begin{bmatrix}\text{Transportation}\\ \text{Cost}\end{bmatrix} = \begin{bmatrix}\text{Weight of}\\ \text{Spare Parts/}\\ \text{Equipment}\end{bmatrix} \times \begin{bmatrix}\text{Transportation}\\ \text{Cost per Pound}\end{bmatrix}$$

Cost Factors	Value	Units
Weight of Spare Parts		Pounds
Transportation Costs per Pound	.50 [1]	$/Pound

[1] This factor was derived by assuming an average distance of 3,000 miles and a cost per pound/mile of $.00013. (3,000 miles x $.00013 per pound/mile = $.49/pound, rounded to $.50 to facilitate computations.)

322.5 Transportation (Alternate)

Cost Formula

$$\text{Transportation Cost} = 2 \times \begin{bmatrix}\text{Unit}\\ \text{Weight}\end{bmatrix} \times \begin{bmatrix}\text{Distance}\end{bmatrix} \times \begin{bmatrix}\text{Cost per}\\ \text{lb/mile}\end{bmatrix}$$

Cost Factors	Value	Units
Unit Weight (Spares/Parts/Equipment)		Pounds
Distance		Miles
Cost per lb/Mile	1/	$/Pound/Mile

1/ Use $.001 for short distances (Distance from Organization to Intermediate is assumed to be 50 miles).

Use $.00013 for long distances (Distance from Organizational/Intermediate maintenance to Depot is assumed to be 3,000 miles).